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THE INTELLECTUAL STATUS OF CHILDREN WHO ARE PUBLIC CHARGES

BY

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ARCHIVES OF PSYCHOLOGY

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R. S. WOODWORTH

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THE INTELLECTUAL STATUS OF CHILDREN WHO ARE PUBLIC CHARGES

The Children Measured

Two hundred and sixty-five children, including one hundred and eighty-three boys and eighty-two girls, were measured. They comprised about three fourths of the children from 9 years 0 months to 16 years 0 months who were, at the time of the investigation, public charges in a certain county. The selection was random except that none of the dependent children sent from the county to the state institution for the care of the feeble-minded were included, and that a few children under nine were tested who probably represented a superior selection from the seven- and eight-year olds.[1] Apart from these, the only selective factor was the omission of some of the smaller institutions *in toto* from the inquiry.

A child may, in the county in question, become a public charge by commitment by an officer of the poor-law on grounds of destitution, or by an officer of the courts on grounds of delinquency; but the line of distinction between the two classes is not at all sharp. The decisive factor is often simply whether the parents are more successful in getting justices to commit their children than in getting poor-law officers to do so.

A comparison of the measurements of the children committed for delinquency with those committed for destitution shows no demonstrable difference either in the tests of abstract intellect or in the mechanical test. So we shall, from now on, for brevity's sake, refer to all these children as ''dependent'' children.

The Tests Used

The Stenquist Test of Mechanical Ability, or Construction Test

The purpose of this test is to measure the child's mechanical ability, the aim being to get as far as possible away from dependence upon the child's ability to read and write and to deal with heard words. The general plan is to measure his ability to select the necessary parts and to put them together properly so as to make certain things, there being seven such tasks, graded in difficulty. The things to be made appear in the upper half of Fig. 1; the parts from which they were to be made appear in the lower half of Fig. 1.

---

[1] These were probably in some measure sent to be measured by the officers of the institution, because they were in classes with older children, or seemed as old as the older children.

The test materials were contained in a wood-lined corrugated paper box, 14 by 16 by 2 inches, with a wood partition through the middle as shown in the illustration, Fig. 1.

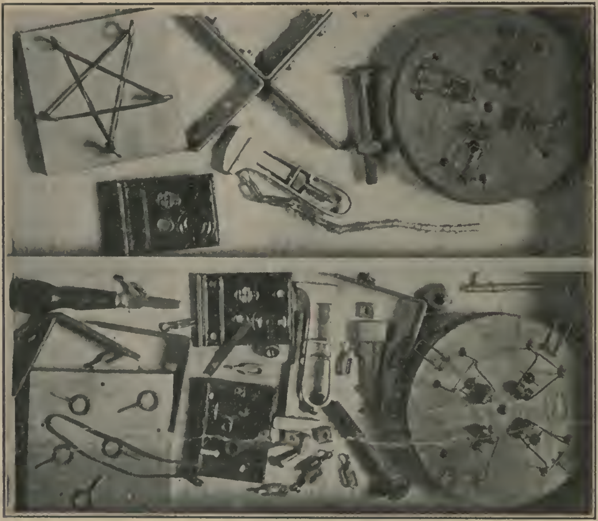

FIG. 1.

They comprise two each of seven mechanical models as listed below and more clearly illustrated under "Standards for Grading."

Model *A:*	
A ⅜ in. by 3 in. carriage bolt with nut	2 parts.
Model *B:*	
A small cast-iron monkey wrench, 4 in. long	3 parts.
Model *C:*	
Three identical wrought iron angle irons, 2½ in. by ¾ in.; four ⅛ in. by ½ in. round head stove bolts, arranged in position shown	11 parts.
Model *D:*	
An ordinary 4-way mouse trap	1 part.
Model *E:*	
Ten links of brass safety chain No. 2	10 parts.
Model *F:*	
One piece whitewood 4 in. by 4 in. by ½ in., drilled with 5 holes, as shown, to form five-pointed star, radius 3⅜ in. Five ⅝ in. screw eyes. One 3½ in. rubber band	7 parts.
Model *G:*	

A simple single-bolt door lock 2 in. by $2\frac{3}{4}$ in. by $\frac{5}{8}$ in. .... 6 parts.

Tools:

One (for complete set) $4\frac{1}{2}$ in. screw driver

Twenty-four children were arranged, one in a seat, in an ordinary classroom. Each child was required to fill out the Record Sheet blank shown below.

Construction Test

Record Sheet

Write your name here ....

Are you a boy or girl? ....

How old were you on your last birthday? ....

What is your teacher's name? ....

What is the number on your box? ....

Do not write anything below this line.

Date ....

School ....

Time:

Setting up ....minutes .... seconds

Taking down .... minutes ....seconds

Quality of achievement on basis of 0 to 10:

Model	*A*	*B*	*C*	*D*	*E*	*F*	*G*
Grade	......	......	......	......	......	......	......

After this blank has been filled out, the following instructions were given: "Lay the paper which you have just filled out on top of your desk near one edge where you can get it easily later." The twenty-four boxes containing the test materials were then distributed. Holding up one of the boxes before them, directions were given as follows: "Turn the box which you have on your desk so that the letter 'F' is toward you. Do not look into the box till I say go.[2] Each one of these boxes is divided into two parts (indicating by gesture how the partition extended across the middle of the box). In the compartment or part farthest away from you there are seven mechanical models, *i. e.,* seven mechanical things; one of them is a bolt with a nut on it; another is a small wrench; another a small chain; and there are four other things.

---

[2] We found it necessary to be very vigilant in keeping the subjects from opening the boxes before the signal was given, as the pressure of curiosity became very great.

''In the part nearest to you there are seven mechanical things just like the others except these are all taken apart. I want you to take all the parts in the compartment nearest you and make seven mechanical things exactly like the ones in the compartment farthest away from you as quickly as you can. As soon as you have finished them all, raise your hand; and we will write on your record sheet just how long it took you to do them all.

''Begin with the one that looks the easiest.

''If you want to take apart any of the models to see how they are made you may do so, but you must put them together again. Screw all the nuts up tight; don't leave them half on, but don't use the wrench to tighten them with. Do you understand?'' (Repeated if necessary.)

''You will now get ready. Grasp the sides of the box so that you can take the cover off quickly when I tell you to. Are you all ready? Go!''

The instructions being somewhat long, we found it necessary after the children began to work to give also the following instructions: this was done after three minutes.

''Do the ones that you think are the easiest first. Screw all nuts up tight with your fingers but do not use the wrench.''

We found that two examiners could manage twenty-four subjects. As soon as a hand was raised, the examiner noted the time from his stop-watch, walked over and entered it on the record sheet of that pupil. The pupil then replaced everything in the box and put his record sheet in the box ready to be graded.

At the end of 30 minutes all children were required to stop work.

The pupil's achievement with each of the seven models was graded on a basis of 0 to 10, as shown in the standards below. All seven models made perfectly in the full 30 minutes then gives a score of 10×7, or 70. An arbitrary value of 1 was given every ''gain-minute''—*i. e.,* for every minute of the 30 that remained after the subject had completed the test. For example, if the subject completed the test in 16 minutes, 12 seconds, 14 points were added to his score. Fractions less than one half minute were neglected. Fractions of more than one half minute were counted as 1.

We found that after a little practise, and with skilled management of boy helpers, one examiner and four boy helpers can grade the twenty-four sets in about 40 minutes.

The illustrations that follow show the value that was assigned to each degree of achievement. It is true that in some cases, as for example in Model *G*, the degrees shown here are not exhaustive. Where an attempted solution was not exactly of any one of the standard types, the grade for the type most like it was given.

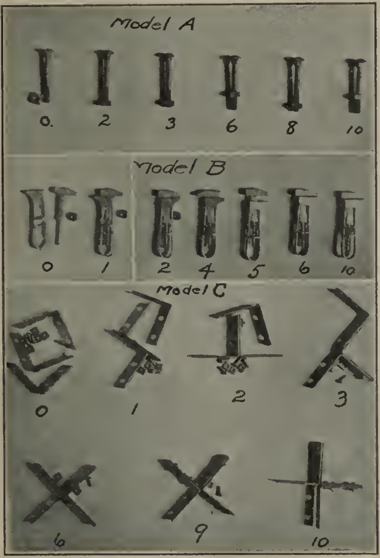

FIG. 2. Standards for Grading Models *A*, *B* and *C*.

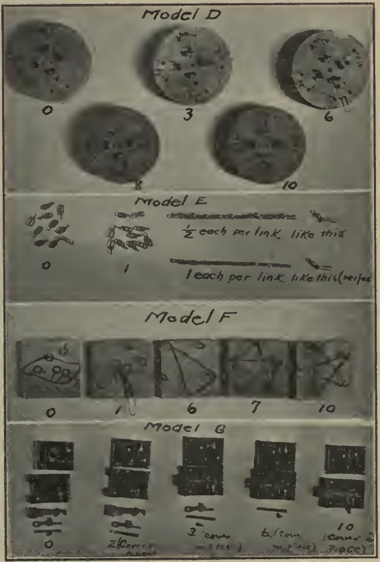

FIG. 3. Standards for Grading Models *D*, *E*, *F* and *G*.

We have then for each child a record like the following samples:

	Score Attained with Model							Credit for Time	Total Score
	A	B	C	D	E	F	G		
Individual 1....	10	10	4	3	0	0	0	0	27
" 2....	10	10	10	10	10	10	3	0	63
" 3....	10	10	10	10	10	10	10	8	78

In order to compare these dependent and delinquent children with ordinary children it is necessary to have knowledge of the achievement of ordinary children with the same test given under the same conditions. The knowledge was obtained as follows:

Four hundred and thirty-two children in two New York City public schools[3] ranging in age from 6 years to 16 years were tested in exactly the same way as were the dependent children. The resulting scores are indicated in Table I. Calculating the median score obtained by each age group we obtain the following (6 = 6 up to 7, etc.) :

---

[3] These schools are frequented by children of parents of (roughly) the small shopkeeper, artisan, and day-laborer classes. The school work is very efficient. We desire to express here our appreciation of the cordial cooperation of Mr. W. H. Maxwell, superintendent of schools of New York City, and of Mr. C. B. Jameson and Miss Ida Ikelheimer, principals of public schools 43 and 68.

Ages:	6	7	8	9	10	11	12	13	14	15
Medians:	34.5	33.75	42.5	51.25	59.3	62.5	66.78	76.4	77.5	82.5

From these data we estimated the probable true central tendencies for these ages as follows:

20	32	42	50	57	63	69	75	79	82

The discrepancies between the obtained medians and the corrected medians are due to the allowance for the fact that the six- and seven-year-olds tested were a selection of specially bright children.

A more exact series of standards for the different ages could have been obtained by determining empirically the allowance to be made for the correlation between progress in school and ability in this test within those of the same age. The labor involved would be great, however, and the gain in exactness small. So it seemed best to use approximate estimates here, reserving a more exact determination of standards until such time as at least a thousand children could be tested.

The construction test evidently needs extension by more difficult tasks than *G*, since after the age of about 12.0, the children of median ability or better can all do the work with practical perfection, so that the score becomes in large measure one of speed of work only. This does not much affect its value as a measure of the mechanical ability of the dependent and delinquent group; for, as we shall see, they do not often enough attain scores of 70 or more.

From these probable true central tendencies or corrected medians the standard scores of Table II. for each year and fraction thereof were obtained. The scores to fit ages below 6.5 and above 15.5 are frankly only estimates.

We then computed the "construction age" of any child by finding that age in Table II. corresponding in score to the score of the child in question. For example, a child receiving a score of 40 is, by the table, 8 years and 3 months, which is here considered as 8.25 years. In cases where the same score appears for several ages, the mid-point was taken. For the three examples of scores noted above (27, 63 and 78) the "construction ages" were thus *7.1*, *11.5*, and *14.3*.

TABLE I

FREQUENCIES OF SCORES ATTAINED BY 432 ORDINARY CHILDREN AS TESTED IN A PUBLIC SCHOOL OF NEW YORK CITY. ARRANGED BY AGES.
6 = 6.0 UP TO 7; 7 = 7.0 UP TO 8, ETC.

Score	Age										
	6	7	8	9	10	11	12	13	14	15	16
4		1									
5		1									
6		1									
7		1									
8	1		1								
9											
10	1		1								
11		1									
12											
13		2	2								
14		2	2								
15	1	1			1						
16		1		1							
17			2								
18		1									
19		1			1						
20		1	1	1							
21		2									
22	1	3	3		1			1			
23			1	1	2	1					
24	2	1	1	1							
25		1	3		2		1				
26	2		2		1						
27		4	1			2					
28	8	1		2	1						
29			2								
30	1	2	1	1							
31		1	1	1							
32		1	1	1							
33			3								
34			1			1					
35			1	2	1	1					
36	2	2		1	3						
37	2	2	1			1		1			
38				1	3		1				
39		1	1								
40		1	1	1	4			1			
41			1			1	2				
42				3		2					
43		1	5	1		5	1	2			
44		2	1	4	1	1					
45		1	2	3	1					1	
46	1	3	1					1	1		
47	1	1	1		1			1			
48	1	2	2	3	2	1	2				

TABLE I Continued

Score	Age										
	6	7	8	9	10	11	12	13	14	15	16
49		2	2	1	1						
50		1	2	2				1			
51	1	1			1	1					
52			1	6	1	1					
53			1		2			3			
54			2				1	1			
55	1	1	1	1	2	2		1	1		
56	1	1	1	1	3	1		1		1	
57		2		2	1						
58			1	2	1	2		1			
59			2			2					
60		1	3	1	1		1		1		
61			1	1	2						
62			1	1	1				1		
63			1	3	3	2					
64		1		1	3	2	1				
65				1	1	2	2				
66		2			1						
67			4	1	3						
68			1	1	2	1	1				
69				2	3	1					
70				2	1	1		1			
71				1	1	2		1	1	3	
72				2		1	1				
73					1		1		1		
74							1	1			
75					2	1		3			
76						2	1	1		1	
77					3	1		1	1		
78			1		3		1	1	3		
79						1		1		1	
80				1	2		2	3	1		
81							1	1		1	
82				1	1	6		2	1	1	
83						1	1			1	
84			1			1		2	2	1	
85					1	2		1			
86					1					1	
87								2			
88						1		3		4	
89								1			
90									1		
91									1		
92											1

TABLE II

CONSTRUCTION AGE-GRADE STANDARD SCORES

Year	Month	Decimal	Score	Year	Month	Decimal	Score	Year	Month	Decimal	Score	Year	Month	Decimal	Score	Year	Month	Decimal	Score
5	0	.0		8	0	.0	37	11	0	.0	60	14	0	.0	77	17	0	.0	87
	1	.1			1	.1	38		1	.1	60		1	.1	77		1	.1	87
	2	.2			2	.2	39		2	.2	61		2	.2	77		2	.2	88
	3	.3			3	.3	40		3	.3	61		3	.3	78		3	.3	88
	4	.3			4	.3	41		4	.3	62		4	.3	78		4	.3	88
	5	.4			5	.4	42		5	.4	62		5	.4	78		5	.4	88
	6	.5	10		6	.5	42		6	.5	63		6	.5	79		6	.5	88
	7	.6	11		7	.6	43		7	.6	64		7	.6	79		7	.6	88
	8	.7	12		8	.7	43		8	.7	65		8	.7	79		8	.7	88
	9	.8	13		9	.8	44		9	.8	65		9	.8	80		9	.8	88
	10	.8	14		10	.8	44		10	.8	66		10	.8	80		10	.8	89
	11	.9	15		11	.9	45		11	.9	66		11	.9	80		11	.9	89
6	0	.0	16	9	0	.0	46	12	0	.0	66	15	0	.0	81	18	0	.0	89
	1	.1	16		1	.1	46		1	.1	67		1	.1	81		1	.1	89
	2	.2	17		2	.2	47		2	.2	67		2	.2	81		2	.2	89
	3	.3	17		3	.3	48		3	.3	67		3	.3	81		3	.3	90
	4	.3	18		4	.3	49		4	.3	68		4	.3	82		4	.3	90
	5	.4	19		5	.4	49		5	.4	68		5	.4	82		5	.4	90
	6	.5	20		6	.5	50		6	.5	69		6	.5	82		6	.5	
	7	.6	21		7	.6	50		7	.6	70		7	.6	82		7	.6	
	8	.7	22		8	.7	51		8	.7	70		8	.7	82		8	.2	
	9	.8	23		9	.8	52		9	.8	71		9	.8	83		9	.8	
	10	.8	24		10	.8	52		10	.8	71		10	.8	83		10	.8	
	11	.9	25		11	.9	53		11	.9	72		11	.9	83		11	.9	
7	0	.0	26	10	0	.0	53	13	0	.0	72	16	0	.0	83	19	0	.0	
	1	.1	27		1	.1	54		1	.1	73		1	.1	83		1	.1	
	2	.2	28		2	.2	54		2	.2	73		2	.2	83		2	.2	
	3	.3	29		3	.3	55		3	.3	74		3	.3	84		3	.3	
	4	.3	30		4	.3	56		4	.3	74		4	.3	84		4	.3	
	5	.4	31		5	.4	56		5	.4	74		5	.4	84		5	.4	
	6	.5	32		6	.5	57		6	.5	75		6	.5	84		6	.5	
	7	.6	32		7	.6	57		7	.6	75		7	.6	85		7	.6	
	8	.7	22		8	.7	51		8	.7	70		8	.7	82		8	.7	
	9	.8	34		9	.8	58		9	.8	76		9	.8	85		9	.8	
	10	.8	35		10	.8	59		10	.8	76		10	.8	86		10	.8	
	11	.9	36		11	.9	59		11	.9	76		11	.9	86		11	.9	

The Trabue Completion Test

The series of fifty-six sentences with omitted words to be completed, as shown below, formed the second test. This test frankly measures intellect as applied to word meanings and relations. It is known to be symptomatic of success with school work in general, and differentiates very clearly a group of twenty dull adults from a group of professional men. We shall refer to it as the omitted-word test, or completion test. This series on the plan of the Ebbinghaus combination test was devised by Mr. Trabue. The method of administering it and scoring it was as follows:

Write words in the empty spaces to make the whole sentence sound sensible and right

1. See .... man and the little boy.
2. We like good boys .... girls.
3. She .... if she will.
4. Here is a man who .... do it.
5. The bird .... a song every morning.
6. The stars and the .... will shine to-night.
7. Good boys .... kind .... their sisters.
8. The wind .... the dust into our eyes.
9. The best .... to sleep is at night.
10. It is good to hear .... voice .... friend.
11. During the .... weather the boys play in the shade.
12. The kind lady .... the poor man a dollar.
13. The little .... and his dog .... running a race.
14. The girl fell and .... her head.
15. The baby's toes are very ....
16. The rude child does not .... many friends.
17. The boy will .... his hand if .... plays with fire.
18. Boys must .... be rude to .... mothers.
19. The stars .... brightly at ....
20. The child .... the river .... was drowned.
21. Boys who play .... mud get their hands ....
22. The poor baby .... as if it were .... sick.
23. When the .... grows older he .... be a man.
24. The .... plays .... her dolls all day.
25. The .... rises .... the morning and .... at night.
26. The boy who .... hard .... do well.
27. The poor little .... has .... nothing to ....; he is hungry.

Write words in the empty spaces to make the whole sentence sound sensible and right

28. .... weather usually .... a good effect .... one's spirits.
29. To .... friends is always .... the .... it takes.
30. .... are times in the .... of almost .... of us when we .... for a long life.
31. Men .... usually more .... to do heavy work .... women.
32. It is very .... to become .... acquainted .... persons who .... timid.
33. A shelter .... the weather is .... appreciated on a .... day.

34. The best advice .... usually .... obtained .... one's parents.
35. A home is .... merely a place .... one .... live comfortably.
36. It is a .... task to be kind to every beggar .... for money.
37. One's real .... usually appears .... often in his .... than in his speech.
38. .... things are .... satisfying to an ordinary .... than congenial friends.
39. The sun is so .... that one can not .... directly .... causing great discomfort to the eyes.
40. Brothers and sisters .... always .... to help .... other and should .... quarrel.
41. Sometimes .... friends would really .... us more by doing .... than by .... to assist us.
42. One can .... much better .... when he is .... worried .... other matters.
43. Many persons .... before they think, and .... do not .... at all; they only talk.
44. When two persons .... about .... which neither understands, they .... almost .... to disagree.

Write words in the empty spaces to make the whole sentence sound sensible and right

45. If a person injures one by ...., without having intended any ...., one should .... insulted.
46. It is very annoying to .... tooth-ache, ... often comes at the most .... time imaginable.
47. .... strange that .... people should show so much .... and .... so .... excitement when a sudden loud .... is heard.
48. When one feels drowsy and ...., it .... happens that he is .... to fix his attention very successfully .... anything.
49. Good company .... it is a great deal .... for an ordinary man to enjoy a .... from work.
50. Children should .... that after all nobody is .... to care much more .... their success than .... parents.
51. If people .... spend their .... and .... more carefully, they could probably save .... than .... usually do.
52. To .... many things .... ever finishing any of them .... a .... habit.
53. The knowledge of .... use fire is .... of .... important things known by .... but unknown .... animals.
54. One .... be very careful in .... advice to unknown persons, for one can .... tell how .... a stranger may .... one's advice.
55. One ought to .... great care to .... the right .... of ...., for one who .... bad habits .... it .... to get away from them.
56. .... that are .... to one by an .... friend should be pardoned .... readily than injuries done by one .... is not angry.

The children were seated at the desks of their regular classroom and provided with pencils. The examiner stood at the front of the room with a set of the test papers in his hand and made the following explanations:

"I shall give each of you three sheets of paper like these I hold in my hand. Please write your name and your age on the back of each sheet. I shall place them on your desk face downward, for I do not want you to read what is printed on the other side until we can all begin at once. Please do no turn the papers over until I ask you to do so. Just write your name and your age at the top of the back side of each one of the sheets as they are placed on your desk."

The examiner then placed face downward on each child's desk a complete set of papers, arranged in order. As he passed them out he again asked them to write their names and ages plainly on each of the three sheets and not to look at the printed side. After the names were all written and everyone was ready again, he explained as follows:

"When I tell you to turn your papers, you will find on the other side some sentences which are not quite complete,—one or two words have been left out, like this." Here the examiner turned to the blackboard and wrote this sentence: "I see ...... cat." He then asked the children to guess what word had been left out. When someone guessed it as "a" and someone else as "the," he had the children to vote on which word he should write in the blank and then wrote the one they selected. He then wrote another sentence: "It ...... a white cat." As soon as some child said "is," the examiner repeated, "'It *is* a white cat.' We only need to write the word 'is' on the little dotted line and we have a good sentence. Now when I tell you to turn your papers you will find on them such sentences as I have written on the board, and I want you to write a word in each blank so as to make good sentences out of them. Put one word in each blank, so that the sentence will sound right and make good sense. Think carefully about each blank so that you will be sure to get the very best word possible. Fill just as many blanks as you can, and fill them just as well as you can. I shall take up the papers in just thirty-five minutes from the time you start, but if anyone gets through in less time he can bring me his paper and get credit for finishing ahead of time. Do not waste time by worrying over a hard sentence. The first page has the easiest sentences and the third page has the hardest ones, so begin with the first page. Now, turn your papers over and see how well you can fill the blanks."

With the smaller children it was sometimes necessary to give some individual instruction, but such cases were very rare. If the child had not understood from the class explanation, it was almost impossible to make him understand by individual help. The examiner always went about the room, however, to do what he could for such cases. If any child finished the three sheets in less than thirty-five minutes, they were taken up and the time was recorded on his first sheet. Thirty-five minutes from the time the children began work, all papers were collected, whether completed or not.

Each child's paper was given a score for each of the fifty-six sentences, each sentence receiving a grade of 5 if perfectly completed, and 0 if not sensible at all. In cases where no words at all were written in the blanks of a sentence, this fact was indicated and given somewhat different treatment from those sentences in which words had been written without making sense. If the sentence as completed by the child was only slightly imperfect, a grade of 4 was given it. When the words supplied seemed to indicate that at least a part of the real meaning of the sentence had been grasped, even though the sentence as a whole was very crude and incomplete, a grade of 1 was given it, and for a slightly better quality a grade of 2 was given. A grade of 3 usually indicated a sentence in which every word written by the child had some reasonable connection with the printed parts of the sentence, although the sentence as a whole was very much inferior to the quality graded 5.

Even with such an outline of the scheme to follow in assigning grades to the sentence, it is doubtful whether two persons would always agree in the values they assigned to some sentences, or even whether the same person would agree with himself at two different times. In an effort to make the grading consistent an objective scale of values was made out for each of the fifty-six sentences, indicating in the case of each sentence that anything equal to the samples under *5* was to be given a grade of 5, and that anything poorer than the highest samples and yet better than the poorest samples under *4* was to be given a grade of 4, etc.

Such a determination of values is necessarily arbitrary and would seem unfair in some ways, but the important thing is to be consistent, which is most easily done by having some objective record to which one can refer. The scheme given below for sentence 30 is typical of the sort of scale that had to be made out for each sentence.

"*There* are times in the *lives* of almost *all* of us when we *wish* for a long life," is by this scheme considered the best rendering of this sentence, although "when we *pray* for a long life" is given just the same score. The asterisk in parenthesis (*), after the word "wish" in the "wish, hope, long, pray" group under *5*, indicates that the word preceding it will thereafter be used as a key word to indicate

30. .... are times in the .... of almost .... of us when we .... for a long life.

5

There .... lives .... all .... $\left\{\begin{array}{l}\text{wish (*)}\\ \text{hope}\\ \text{long}\\ \text{pray}\end{array}\right.$

There ....$\left\{\begin{array}{l}\text{experience}\\ \text{life (*)}\\ \text{history}\end{array}\right\}$.......... everyone .... wish*

4

There ...... life* ...... all ...... wish*

There ...... lives ...... all ......$\left\{\begin{array}{l}\text{ask}\\ \text{seek (*)}\\ \text{look}\\ \text{pine}\\ \text{prepare}\\ \text{wished}\\ \text{fight}\end{array}\right.$

There ...... $\left\{\begin{array}{l}\text{lives .... all}\\ \text{life* ...... everyone}\end{array}\right\}$ ...... $\left\{\begin{array}{l}\text{wish*}\\ \text{seek*}\end{array}\right.$

There ......$\left\{\begin{array}{l}\text{minds}\\ \text{days (*)}\\ \text{years}\end{array}\right\}$...... all ...... wish*

3

There ...... days* ...... all ...... seek*

There ......$\left\{\begin{array}{l}\text{midst}\\ \text{heart (*)}\\ \text{world}\\ \text{soul}\\ \rule{3em}{0.4pt}\end{array}\right\}$...... all ......wish*

There ...... days* ...... any ...... seek*

There ...... life* ...... $\left\{\begin{array}{l}\text{all}\\ \text{any}\end{array}\right\}$ ......$\left\{\begin{array}{l}\text{want}\\ \text{live (*)}\\ \text{suffer}\end{array}\right.$

There ...... lives ...... $\left\{\begin{array}{l}\text{many}\\ \text{every}\end{array}\right\}$ ...... seek*

There ...... lives ...... all ...... $\left\{\begin{array}{l}\text{good}\\ \rule{3em}{0.4pt}\end{array}\right.$

2

There ...... hearts* ...... all ......live*
Hard ...... lives ...... everyone ...... wish*

There ...... days* ...... all ...... $\left\{\begin{array}{l}\text{live*}\\ \text{die}\end{array}\right.$

There ...... day ......$\left\{\begin{array}{l}\text{all ......}\left\{\begin{array}{l}\text{live*}\\ \text{time}\end{array}\right.\\ \text{one ...... ask}\end{array}\right.$

Their ...... future ...... all ...... live

There ...... $\left\{\begin{array}{l}\text{hearts*}\\ \rule{3em}{0.4pt}\end{array}\right\}$ ...... (———) ...... wish*

1

There ...... hearts* ...... (———) ...... live
There ...... day ...... one ...... die
There ...... days* ...... (———) ...... {are
There ...... (———) ...... (———) ...... {———

0

———} ...... (———) ...... (———) ...... live*
You ...... spring ...... good ...... spent

the whole list. Thus, in the first line under *4*, the word "life*" stands for the "experience, life, history" group, and the word "wish*" stands for the "wish, hope, long, pray" group. Using key words in this way makes it possible to actually know what one has given a certain combination of words, even though he did not write out in full each combination as it came up.

In making use of this sort of scheme the grader has at first to watch the key words carefully. For instance, if he met the sentence "*There* are times in the *years* of almost *all* of us when we *prepare* for a long life," he would have to find "years" in the group whose key word is "days," and "prepare" in the group whose key word is "seek." Then looking for the combination "There......days*.....all......seek*," he would find that it was rated as a high 3 and would score his sentence as 3.

One very soon comes to recognize about where any combination comes in his scheme of values, and then it is not necessary to hunt out each time the combinations of key words. In fact, one has to guard against depending too much on his mechanical device and failing to exercise his judgment at all. It would be almost impossible as well as very confusing to try to keep a record of each variation that occurred. Some objective record of one's judgments is necessary, but it is very easy to get so many that they hinder rather than help, especially in the lower quality specimens.

After the sentences were graded, they were grouped, for purposes of calculation, into eight groups of seven sentences each. I shall hereafter refer to these eight groups as the eight sections, for each group was treated as an independent unit in the record. The first section, then, was composed of the first seven sentences; the second section, of sentences 8–14; the third section, of sentences 15–21; the fourth section, of sentences 22–28; the fifth section, of sentences 29–35; the sixth section, of sentences 36–42; the seventh section, of sentences 42–49; and the eighth section, of sentences 50–56. Since each sentence which was perfectly completed received a score of 5 and there were seven sentences in each test, a perfect score in any section would be 35. In this way eight scores of from 0 to 35 were obtained for each child.

The score of each child in each of the eight sections was then expressed in terms of the performance of public-school children in the same test. If, for instance, a child had made a score of 30 in the first section, 25 in the second, and 28 in the third, he was recorded as having done as well in the first section as the median public-school child 9.3 years old, and in the third section as well as the median public-school child 9.6 years old.

Derivation of Standards.—The standards of performance by public-school children were obtained from tests given during April and May to 850 children in Public School No. 68 and Public School No. 43, Manhattan. The tests given the public-school children were the same as those given to the dependent children, were given in the same way, under practically the same conditions, and were graded by the same standards.

A typographical error in the 25th sentence as it appeared on the test sheets given to some of the children in the public schools made it necessary to leave it out of the calculations entirely. For this reason the fourth section as here reported consisted of sentences 22, 23, 24, 26, 27, and 28, and a perfect score in this test would be 30 rather than 35.

The score made by each public-school child in each of the eight sections was determined, as in the case of the dependent children, by adding the grades made in each of the seven sentences composing the section. A table of distribution was made for each of the eight sections, showing the number of times each score (0, 1, 2, 3, 4, 5, 6, 7–35) was made by all the children together, by the children of each age, and by the children of each age in each school grade. The following table (Table III.) of distribution is a portion of the distribution for section V. The entire table for each section ranges from age seven to age fourteen, and from Grade 2*A* to Grade 8*B*, but this small portion showing the performance of ten- and eleven-year-old children in one of the sections, will be sufficient to illustrate the method that was used.

Reading across the top of Table III. from left to right, one sees that the score of 0 was made by two ten-year-olds in the 3*A* grade, by one of the same age in the 3*B* grade, and by another in the 4*B* grade, making a total of four ten-year-old children who failed to make any score at all on the fifth section. All of the eleven-year-old children who were tested in the public schools made some score above 0 in this section. An examination of the column headed Total shows that six ten-year-old children made a score of 1, five a score of 2, four

TABLE III

Distribution of Scores in Section V., Sentences 29–35., of Public-school Children of Ages 10 and 11 Years (10.0 to 11, and 11.0 to 12)

	Age 10									Age 11									
Score	*3A*	*3B*	*4A*	*4B*	*5A*	*5B*	*6A*	*6B*	Total	*3A*	*3B*	*4A*	*4B*	*5A*	*5B*	*6A*	*6B*	*7A*	Total
0	2	1		1					4										
1		1	4	1					6	1				2	1				4
2	1	2	1	1					5		2	2							4
3	1	1	1		1				4				2						2
4	1	1	1			1			4			1	1		1				3
5	1		3	1		1			6		2	1	1	1					5
6	1	3	4						8				1		1	1	2		5
7		1	2		2				5			1			1				2
8			2						2			1			2		2		5
9			1			1			2			1		1	2		1		5
10				4	1	1			6				2		1				3
11			1	1		1			3			1	1	2	5	1			10
12				1		2	1		4				1	2	5	2	2		12
13						4	2		6						1	2	1		4
14			1			1	1		3					2	2		1		5
15						1	1		2						2		2		4
16						1			1					1	4	1			6
17			1			1			2						2	1	1		4
18			1						1						1		1		2
19																	2		2
20					1			1	2					1		1			2
21			1				1		2									1	2
22				1					1										
23															2			1	3
24						1			1								1		1
25																			
26							1		1										
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
No. of Cases.	7	10	24	11	5	16	7	1	81	1	4	8	9	12	33	9	17	2	95
Med. Score..	3	3.5	6	10	7	13	14		7			6	6	11.5	12	13	14		11

a score of 3, etc. There is a surprisingly large amount of variation in the score made by ten-year-old children. An examination of the table shows that a child is more likely to make a good score in this section of the completion test if he is in the fifth or sixth school grade than he is if he is only in the third or fourth grade. This indicates that there is some relation between the ability which this test measures and the judgment of the school authorities who promote children from grade to grade. This has since been proved definitely to be the case, and to a fairly high degree.

As a single figure to indicate the ability of the children here tested, the median seems best. The median child is that child whose ability is central,—who has just as many above him in ability as he has below him. Since there are eighty-one children ten years old, the median child will be the forty-first in the column of totals. Counting downward from the low scores toward the high ones, one finds the forty-first to be the fourth one of the five who made a score of seven, so that the median child ten years old made a score of seven. The mode, or the score most frequently made by these same children, was 6. In a similar way the median of the scores made by eleven-year-old children in this section of the completion test will be found to be 11, and the mode 12.

The median score made by all the ten-year-olds tested is probably not the best representative of the ability that should be shown by children ten years old, for the children tested were not truly representative of all ten-year-old children in every respect. More classes were tested in the lower grades than in the upper, so that ten-year-old children who were in the higher grades and who would have made good scores did not have the weight of numbers that those in the lower grades had. It seems likely therefore that 7 is somewhat too low.

In order to reduce the chance of errors of this kind, it seemed best to use the median of the scores made by *those children who had made normal progress in school.* An examination of the ages of the children in the schools tested seemed to indicate that normal progress in these schools would put the child in the 1*B* and 2*A* grades at the age of seven, 2*B* and 3*A* at eight, 3*B* and 4*A* at nine, 4*B* at ten, 5*A* and 5*B* at eleven, 6*A* and 6*B* at twelve, 7*A* and 7*B* at thirteen, and 8*A* and 8*B* at fourteen. These grades were used as "normals" in the calculations which follow. Reference to the medians for each grade of ten-year-olds at the bottom of Table III shows that the median score of ten-year-old children who are in the 4*B* or normal grade is 10. The number of cases is too small to fix this definitely, but reference to other medians show that it is not far wrong. In a similar way the median score in section V. of those eleven-year-old children who have made normal progress and were in the 5*A* and 5*B* grades, is 12.

"Ten-year-old children" here means those children who are from 10.0 up to 11.0 years old, therefore those averaging 10.5 years. Similarly the eleven-year-olds average 11.5 years. To say that eleven-year-olds who have made normal progress make a median score of 12 in section V. really means then, that children 11.5 years old should make a better score than 12 as often as they make a poorer. In a similar way the twelve-year-old children, who average 12.5 years old and are in the sixth grade, make a median score of 14 in section V. The medians found for each normal age group in each one of the eight tests were as follows:

TABLE IV

MEDIAN SCORES IN EACH SECTION OF THE COMPLETION TEST FOR EACH YEAR-AGE. GROUP OF ORDINARY CHILDREN

Age	I	II	III	IV[4]	V[4]	VI[4]	VII[4]	VIII[4]
8.5	24	14	19	15	4	4	0	0
9.5	30	26	28	18	5	5	2	0
10.5	30[5]	30[5]	31[5]	21[5]	10[5]	7[5]	4[5]	0[5]
11.5	31	30	32	23	12	14	8	2
12.6	34	31	31	23.5	14	15	8.5	5.5
13.5	34	32	33	26	17	18	16	13
14.5	34.5	34	32	27	21	20	17	11

The gain in score from the lower ages to the higher is not always constant in these tests, or rather it does not appear constant in the medians shown above. One of the main reasons for this irregular progress is the small number of pupils used in determining these points. The points fixed by the above medians were plotted so as to

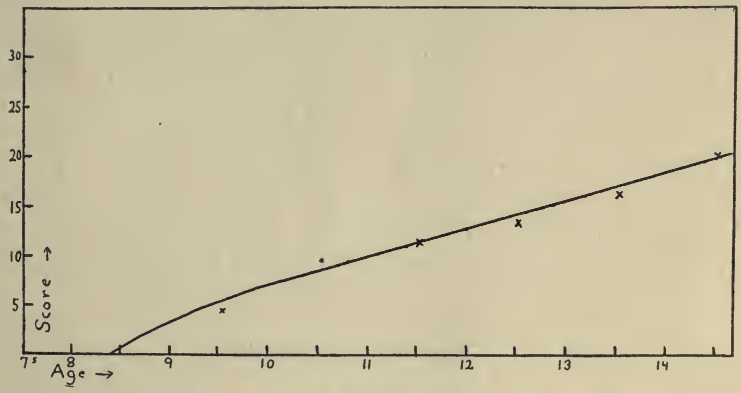

FIG. 4. A cross indicates a median established by normal age group containing two school grades. A dot indicates a median established by normal age group containing only one school grade. The curve as given has been smoothed out by reference to factors determining the medians.

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[4] Sections IV.–VIII. were not given to the children in the second grade, so that the medians here given for children 8.5 years old are somewhat high.

[5] Medians for children 10.5 years old are less reliable than others, for they are based on the records of only eleven children.

show the curve of rising ability as the children become older, and then the irregularities of these curves were smoothed out by reference to the facts connected with their determination and the laws of probability. The graph on p. 19 shows the medians established for section V. and will serve very well to show how the curve was smoothed out in the case of all eight sections.

It will be noticed that in drawing the curve relatively more weight is given to the medians established for children 11.5 and 14.5 years old than is given to the others. This is because these two medians were more accurately determined and depend on a larger number of cases. The median for age 8.5 does not depend on all the normal progress group; for the *2B* children were not given this test, and therefore this median, determined by using the brightest half of the normal progress pupils, is probably a few points too high. For that reason the smoothed curve passes below the median determined.

After smoothing out each section's curve as carefully and accurately as possible, it was again turned into a table of values. This table (Table V.) shows approximately the normal age of a child who makes a given score in each of the eight sections of the completion test.

By means of this table one can easily turn the gross score made by a child in any one of the eight sections into a ''normal age'' figure which is not far from accurate. It must, however, be borne in mind that these standards are for children of normal age and grade in the two particular public schools which were tested. It is probable that further tests in other schools will modify these values.

The crude score obtained by each of the dependent and delinquent children in each of the eight tests was turned into a normal-age figure by means of Table V. It was not expected that the boy who did as well as a normal child 9.2 years old in the first section would do exactly the same as the normal child 9.2 years old in the second and all the following sections of the test. Many factors enter in to make the result obtained by the same person in the same sort of work different at different times. For comparison with other tests, however, a single figure indicating the central tendency of the individual's ability is desirable. Here again the median is the best expression of the central tendency and is used to represent the child's ability in completing these sentences. If a child is recorded as 10.3 in the completion test, it means that he did better than ''normal progress'' children of that age in these two public schools as often as he did less well than they.

Cases in which no result at all was attained in completing the sentence in certain sections were not counted in calculating the median of the results from the entire eight, unless the median of

TABLE V

AGES CORRESPONDING TO EACH DEGREE OF ACHIEVEMENT IN EACH SECTION OF THE COMPLETION TEST

Sec. No. Score	I	II	III	IV	V	VI	VII	VIII	Score
1		7.6	7.6	7.7	8.4	8.7	9.1	11.3	1
2		7.6	7.6	7.7	8.6	8.8	9.5	11.5	2
3		7.7	7.7	7.8	8.8	9.0	9.8	11.7	3
4		7.8	7.7	7.8	9.0	9.2	10.2	11.9	4
5		7.9	7.8	7.8	9.3	9.4	10.5	12.1	5
6		7.9	7.8	7.9	9.5	9.6	10.8	12.4	6
7		8.0	7.9	7.9	9.8	9.8	11.2	12.6	7
8		8.1	7.9	8.0	10.2	10.0	11.5	12.9	8
9	7.5 —	8.1	8.0	8.1	10.5	10.3	11.9	13.2	9
10	7.5	8.2	8.0	8.2	10.8	10.5	12.2	13.6	10
11	7.6	8.3	8.1	8.3	11.2	10.7	12.5	14.0	11
12	7.6	8.4	8.1	8.4	11.5	11.0	12.9	14.7	12
13	7.7	8.4	8.2	8.5	11.9	11.3	13.2	14.5 +	13
14	7.7	8.5	8.2	8.7	12.2	11.7	13.5		14
15	7.8	8.6	8.3	8.9	12.6	12.2	13.9		15
16	7.9	8.6	8.3	9.1	12.9	12.7	14.2		16
17	7.9	8.7	8.4	9.3	13.2	13.2	14.5		17
18	8.0	8.8	8.5	9.5	13.6	13.6	14.5 +		18
19	8.1	8.8	8.6	9.8	13.9	14.1			19
20	8.1	8.9	8.7	10.2	14.3	14.5			20
21	8.2	9.0	8.7	10.5	14.6	14.5 +			21
22	8.3	9.0	8.8	11.0	14.5 +				22
23	8.4	9.1	8.9	11.5					23
24	8.5	9.2	9.0	12.3					24
25	8.6	9.3	9.2	13.1					25
26	8.7	9.5	9.3	13.8					26
27	8.8	9.9	9.4	14.5					27
28	9.0	10.3	9.6	14.5 +					28
29	9.2	10.8	9.8						29
30	9.9	11.5	10.1						30
31	10.9	12.3	10.5						31
32	11.9	13.0	11.5						32
33	12.9	13.8	14.5						33
34	13.9	14.5	14.5 +						34
35	14.5 +	14.5 +							35

those sections in which an effort had been made was within .3 of a year of being as high as the lower limit of the scale for the section which had not been touched. For example, if a child had shown a median ability of 9.2 in the first seven sections, it would not be expected that he would make any score in section VIII., for the child who made a score of 1 in section VIII. was as often older than 11.3 as younger. If the median of the results for the first seven sections was above 11.3, however, the child clearly had sufficient ability to at least attempt the eighth test, and failure to do so was counted the same as if he had attempted it and failed. If the median of the results of the first seven sections was between 11.0 and 11.3, we used our best judgment as to whether section VIII., being left untouched, meant a failure or lack of ability to try,—that is, whether to count it as a low score and use it in calculating the median, or to ignore it and calculate the median on the basis of the first seven sections.

Any section which was not touched was treated in the same manner. If the median result for those sections which were attempted was equal to or higher than the age figure for a score of 1 in the section in question, the test was used counting as a failure in calculating the median given in this report. But if the median result of the other section was lower than the age figure for a score of 1 in the section in question by more than .3 of a year, the section was not used in calculating the median reported. If the median of the other sections, however, was not quite as high as the lowest age figure of the section in question, but was within .3 of a year of it, it was counted or not according to the best judgment that could be made concerning it.

The various steps of this rather elaborate system of scoring may be illustrated by the three following cases, beginning with the gross totals obtained for the eight sets of seven sentences each.

Gross Totals for Sets of 7 Sentences

Individual	1–7	8–14	15–21	22–28	29–35	36–42	43–49	50–56
A	15	8	17	15	2	4	0	0
B	29	28	30	24	14	11	0	0
C	16	13	18	4	1	1	0	0
D	35	33	33	28	18	14	13	8

Inferred Completion-Ages on the Basis of Each Set of 7 Sentences

Individual	1–7	8–14	15–21	22–28	29–35	36–42	43–49	50–56
A	7.8	8.1	8.4	8.9	8.6	9.2	9.1 —	11.3 —
B	9.2	10.3	10.1	12.3	12.2	10.7	9.1 —	11.3 —
C	7.9	8.4	8.5	7.8	8.4 —	8.7	9.1 —	11.3 —
D	14.5 +	13.8	14.5	14.5 +	13.6	11.7	13.2	12.9

Individual	Median Inferred Mental Age by Completion Test as a Whole
A	8.5
B	10.3
C	8.2
D	13.7

The Binet-Simon Tests

The Goddard revision of the Binet-Simon tests was the third series of tests used, the following being the procedure:

The Binet tests were given to boys 1–50 between the 18th and 25th of July, to boys 51–98 between the 18th and 24th of June, to boys 99–141 between the 24th and 30th of June, and to boys 142–183 between the 7th and 19th of December. The girls numbered 200 to 256 were given the Binet tests on the 6th, 7th, 8th, and 17th of July, and the girls numbered 257–281, on the 18th, 22d, 24th, and 25th of the same month. Sixteen of the boys and thirty of the girls were tested by Mr. Stenquist, the rest by Mr. Trabue.

The Binet tests were uniformly given at least a day after the class tests (described elsewhere), so that the examiners were not strangers to the children tested. The examiner sat at a table in one of the classrooms with which the children were thoroughly familiar, and no one but the child to be examined came in, except occasionally when some errand kept one of the officers of the institution busy in some distant part of the room. A chair was provided for the child to sit comfortably at the table beside the examiner, and every possible effort was made to have the external conditions as pleasant as possible.

The hours for testing were from nine until twelve o'clock in the morning and from one until five-thirty o'clock in the afternoon. The time required to give the tests to each child varied from a half hour to three quarters of an hour, according to the age and condition of the child being tested.

The method adopted for giving the tests was in general that described by Dr. Henry H. Goddard in *The Training School,* January, 1910. The forms for keeping the child's record and the weights, pictures and other apparatus for giving the tests were those furnished by the C. H. Stoelting Company, of Chicago. The procedure was as nearly the same in each case as was possible without making the examiner a mere automaton.

The pleasant spirit of earnest effort which had been present in the class tests appeared also in these individual tests. Without exception the children appeared to enjoy doing just as they were asked to do, and their efforts were uniformly encouraged, whether they were successful or otherwise. The child was not informed even by the examiner's tone whether he had answered the question correctly or not. The child was allowed to see that his words were sometimes copied, but he was never allowed to see any mark indicating success or failure.

As each child came into the room to be tested he was greeted by a smile and a "Good morning," or "Good afternoon," from the examiner. The chair in which the child was to sit was pushed back to emphasize the verbal invitation, which was usually given in these words: "Come right up and sit down. I'll be ready in a moment—just as soon as I look over this paper." This gave the examiner time to calculate the mental age of the child who had just been examined and to make any notes necessary concerning his behavior and physical character, and it also gave the new child an opportunity to get adjusted to the situation.

After completing the record of the previous child, a new test sheet was taken and the examiner turned to the child by his side. "Let's see. What is your name?" As this question was asked the examiner turned to his record of the class tests of mechanical ability and endeavored to get on good terms with the child by telling him how well he had done in that test. "Oh yes, Johnny Jones. You did quite well on your other tests. You put the wrench together well, and you set the mouse trap all right, didn't you?"

Taking up the test sheet to write the child's name and age, the examiner continued: "How do you spell your last name, 'J o n e s?' I thought so. When is your birthday, Johnny? 'January 5th.' How old will you be next January, Johnny? 'Twelve.' Then you are about eleven and a half years old now, are you not? And you were born on January 5, 1903. Is that right?" This effort to get things just right, to avoid misspelling the name, and to show a personal interest in the child, usually made the child feel quite at home and removed any tendency to reticence. It was found to be more reliable to ask the child how old he would be at his next birthday than to ask how old he was at his last birthday. It was also found that many of them were not exactly sure of the year in which they were born. Each was fairly sure as to his age, however.

After writing the child's name and date of birth at the top of the sheet, the third piece of information called for was the date. "What date is to-day? Do you know?" If the correct answer was given, the date was written without comment, but if it was not known or was incorrectly given the examiner did not write the date until afterwards, in order that the child should not see that he had made a mistake. Two of the questions already asked constituted integral parts of the test: knowing name (III., 5) and knowing date (IX., 3). Both are so easy, however, that they gave hardly any information about the children we were testing, and the children themselves were not aware that the test had begun.

The standards of performance to be counted as satisfactory and the credit to be given for each test, as well as the form in which the test was presented, were those described by Dr. Goddard, except where study of the methods used by others and the examiner's own experience convinced him that modifications were desirable. It may be understood then, that the tests were identical with those of Goddard, except where mention is made of a different form.

The first test given after filling in the data at the top of the test sheet, was the test of memory for numbers (III., 3; IV., 3; VIII, 5; X., 3; XII., 1). This test was chosen to be given first because it gives the quickest indication of the child's level of ability, it is easily understood by the child, it begins at a point where any of our children could do it successfully, and it gets the child into an attitude of attention which is very valuable. In many respects this tests is the easiest to administer of the Binet series. The explanation of the test was as follows: "Now, Johnny, I want to see first how many numbers you can remember. I will repeat some numbers while you listen, and as soon as I am through I want you to try to say them just as I did. Now listen." The experimenter always made a point of beginning with such a short list that the child would be sure to remember all, then gradually he increased the number of digits until the child was unable to get all of them correctly in one trial out of three lists of the same length. The time between digits of the same list as pronounced by the examiner was about $\frac{3}{4}$ of a second. Each was pronounced independently, so that no connecting rhythm might aid the child.

Immediately following the test for memory for numbers, the memory tests for sentences were given (III., 2; V., 3; XII., 3). A sentence intermediate between V., 3 and XII., 3, was given (without credit) as follows: "Mary is a splendid little girl. She likes to sew and does it very well."

The results from these two series of memory tests gave a good indication of where to begin with the other tests. For convenience in presenting the tests and in order not to confuse the child by continually changing the method of work, we grouped the tests according to their methods of application into several parallel groups. Each group was given separately, beginning at a point where the child would be sure to be successful, or at least where the memory test had given promise that he would be successful, and going from the easy to the more difficult until the child showed clearly that he was unable to do any that were more difficult. No child was given all the tests of any group, but each was given all those in any group between the point where he showed full ability to do anything easier and the point where he showed complete inability to go higher.

The first of these parallel groups was one in which no apparatus was necessary, the tests being largely conversational in character. This group was composed of the following: III., 1; IV., 1; VI., 1; VI., 4; VIII., 2; VIII., 3; IX., 4; X., 4; XI., 1; XI., 4; XII., 5; XV., 2; XV., 4.

As soon as the child's upper limit in the first group of tests had been found, another series was begun which required more activity on the part of the child. This series consisted of the following tests:

V., 2; V., 5; VI., 4; VII., 4; X., 2; X., 5; XI., 2; XI., 3; XII., 3; XV., 3.

A third group of tests was composed of those having to do with money: V., 4; VII., 1; IX., 1; X., 1. A fourth group of tests was composed of those calling for definitions: VI., 2; VIII., 1; IX., 2; XII., 2.

Another large group of the tests was composed of those which require apparatus or specially prepared objects. These were as follows: III., 4; VII., 2; XV., 1;[6] IV., 2; IV., 4; V., 1; VI., 5; VII., 3; VII., 5; VIII., 4; IX., 5; XI., 5; XII., 4.

As indicated above, this grouping of the tests was made for the sake of convenience in giving them, and does not pretend to divide them according to the abilities which they test. An ascending scale for each sort of ability tested would be very desirable, but the tests for memory of numbers and memory of sentences are the only ones which approach this in the Binet series.

Dr. Goddard gives the child credit for mental ability of the highest age for which all the tests are passed; and .2 of a year additional credit is given for every test above this age. This scheme was followed in calculating the scores of the dependent children, with the additional rule that .2 of a year should be subtracted for every failure below the age in which all the tests had been passed. This was necessary because the method of giving parallel groups of tests rather than age groups discovered the fact that some children who pass all the tests for a given age are yet unable to pass some of the lower tests. It was also rather common for a child to fail on all the tests for a given age and yet pass some of those which were above that age. This possibility seems to have been overlooked by Dr. Goddard, whose instructions are to go down the list until all the tests for a given year are passed and up the list until the child fails in all the tests for a given year.

The mental ages as calculated by the Binet-Goddard scheme are, after 8.6 years, too low for ordinary American children, whatever they may have been for French children. The average or median American child 11 years 0 months old will not score 11.0 by the Binet test, but about 10.6. The average or median child 13.0 years old will not score 13.0, but about 11.4. The available data have been worked up by one of us (see the *Psychological Clinic,* Vol. VIII., No. 7) and show the values of Table VI. to be approximately correct for various Binet scores from 7.0 years to 12.0 years.

Consequently the Binet score for each dependent child has been transmuted in accordance with Table VI. into the age whose ability it really represents in the case of ordinary American children. These latter we shall call the *"Corrected Binet"* ages.

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[6] The four pictures used were those of the Barber, the Shoemaker, the Butcher and the Gardeners.

TABLE VI

Binet Score Computed as Stated Above	Median Age Corresponding Thereto	Binet Score Computed as Stated Above	Median Age Corresponding Thereto
7.0	6.8	9.6	9.8
7.2	7.0	9.8	10.0
7.4	7.3	10.0	10.3
7.6	7.5	10.2	10.5
7.8	7.8	10.4	10.8
8.0	8.0	10.6	11.0
8.2	8.2	10.8	11.6
8.4	8.4	11.0	12.2
8.6	8.6	11.2	12.6
8.8	8.9	11.4	13.0
9.0	9.1	11.6	13.4
9.2	9.3	11.8	13.8
9.4	9.5	12.0	14.2

The Reading Test

The fourth test was of the ability to read certain passages and answer questions or perform acts based on them—a test intended definitely to measure what these children had got from the educational opportunities of school and home. The passages and questions were those of sets *A, B, C, D, E, F, V* and *X*, a printed in the Teachers Collge Record of September, 1914. We shall call this the reading test.

This test gives us in some measure a means of discriminating between constitutional dullness and lack of training. In so far as the children do well in the Binet test where the bulk of the work is oral and do poorly in this reading test, their deficiencies may be assigned to lack of opportunity and stimulus. If, on the other hand, they are just as inferior in the Binet tests as in this reading test, their deficiencies may be probably (not surely) assigned in large measure to inherent lack of capacity. The matter is not sure, for it is not absolutely certain that the abilities required by the Binet test are less dependent on home and school training than those required for intelligent reading.

The reading test was given and scored as follows:

Reading tests *A, B, C, D, E* and *F* were usually given just after the completion tests, although the noon hour intervened in a few instances. The children were provided with pencils and seated at the desks of their regular classroom. The examiner held in his hand a set of the tests and explained to them as follows:

"I am going to give each of you three rather long sheets of paper like these I hold in my hand. I shall place them on your desk face downward, for I do not want you to see what is printed on the other side until everyone is ready and knows what to do. Write your name and age at the top of each one of the papers without turning it over. Do not turn the papers until I tell you. Just write your name and age at the top of the back side of each one of the sheets as it is placed on your desk."

He then placed face downward on each child's desk a complete set of the papers, arranged in order. As he passed them out he warned them again: "Write your name and age, but do not look at the printed side of the papers." He then made further explanations as follows:

"If you have your name and age written on each sheet given you, I will explain what we are going to do. When I give the signal to turn over your papers, you will find printed on the other side some little paragraphs telling stories about someone, and some questions for you to answer about the stories. Suppose the story says that 'John and Mary went to town yesterday,' and then suppose the question asks 'Who went to town?' What would you write? Of course, you would simply write the answer, 'John and Mary,' on the line just after the question. There are six little stories and several questions about each story. Read the little story marked '*A*' first, and then answer the questions about it. Write your answers on the lines following the questions. After you have answered all the questions under story *A,* read story *B* and answer the questions about it. Take them in order; do *A* first, then *B,* then *C,* then *D,* then *E,* and then *F.* Write the answers to just as many questions as you can and make the best answers you can. You will find the answers in the little story, so be sure you understand what the story says. When you have answered all the questions you can, just as well as you can, hold up your hand and I will mark down the time it has taken you to do it. I shall have all of you stop in thirty minutes, but I want to see how many of you will get through before I stop you. Is there any one who does not understand? Then you may all turn your papers over and read the story under *A.*"

It was always necessary to go around and help some of the younger children to get started, in spite of the long explanation. In cases where it was necessary to give personal assistance to any child, his paper was marked with an "Expl." As soon as a child had finished all three sheets of the test, the examiner marked on the first page the time it had taken him and took up his papers. At the end of thirty minutes, the signal was given to stop writing and the papers were all collected.

The reading tests *X* and *V* were given immediately after the reading tests had been collected. The examiner held in his hand the two sheets, *X* and *V*, and explained as in the previous case that he would place the papers on their desks face downward, and that they were to write their names and ages on the backs of each sheet given them. After passing out the tests and getting each child to sign them on the back as before, he made this explanation:

"When I give the signal to turn your papers, you will find printed on the other side all the directions as to what you are to do. Just read what it says to do under the letter *V*, and then do it. Be sure to do just what it says and nothing more. Be very careful, for in some places the man who wrote these directions tried to see if he could catch you when you were not thinking. After you have done everything on the sheet marked *V*, take the sheet marked *X* and do what it says to do there. Remember to do just exactly what it says to do. I will give you fifteen minutes to finish both papers, but if any of you get both of them done in less than that time hold up your hand and I will give you credit for finishing ahead of time. Is there any one who does not understand? Then you may all turn your papers over and do what its says to do."

In this case also it was necessary to give personal directions to a good many children, but as before such papers were marked "Expl." so that such assistance could be allowed for in grading the papers. As soon as any child had finished both papers the time it had taken him was marked on the first page and both papers were taken up. At the end of fifteen minutes all the papers were collected.

Scoring.—Scores of 0, 1, 2, 3 or 4 were given to each division of *A, B, C, D, E, F*, and scores of 0, 1 or 2 to the divisions of *V* and *X*, according to adequacy of the child's work,[7] and the scores so given were combined for *B* and *C*, for *D* and *E*, for *F*, and *V* and *X*. By the system used, the maxima obtainable were 64 for *B* and *C*, 72 for *D* and *E*, 32 for *V* and *X*, and 40 for *F*. (*A* was left out of account, it being intended to serve as an introduction to the test proper.) We have, for example, for a certain child 60 points out of a possible 64 for *B* and *C*; 52 out of a possible 72 for *D* and *E*; 13 out of a possible 32 for *V* and *X*, and 16 out of a possible 40 for the difficult *F*. This child would then be given, as his " reading age " by all four scores, the age at which the ordinary child would attain an equal result. For the child in question these reading ages were 9.9, 10.2, 10.7 and 11.6, since the score of 60 in *B, C,* is made by the average child at the age of 9.9 years; the score of 52 in *D, E,* is made by the average child at 10.2 years; the score of 13 in *V, X,* is made by the average child at 11.8 to 12.0 years, and the score of 16 in *F* is made by the average child at 11.6 years.

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[7] Details concerning the assignments of the values 1, 2, 3 and 4 may be found in the *Teachers College Record* for September, 1914, pp. 48 ff.

The standards defining the achievement of ordinary children in these reading tests were obtained from about 700 children tested in a public school on the upper east side of New York City, representing homes of the general intellectual class of small storekeepers, artisans and clerks. As the "average" 9.5 year old, we used the children 9 years 0 months to 9 years 11 months in grades 2*B* and 3*A* in June; as the "average" 10.5 year old, we used the children 10 years 0 months to 10 years 11 months in grades 3*B* or 4*A* in June; and so on as shown below. These grades seemed to represent about the degree of school progress of the average child in the school in question. The results from less advanced and from more advanced children were also given some consideration in determining the standard.

9½-year-olds (9.0 to 9.9) in grades 2*B* and 3*A* used to represent average ability.
10½-year-olds (10.0 to 10.9) in grades 3*B* and 4*A* " " " "
11½-year-olds (11.0 to 11.9) in grades 4*B* and 5*A* " " " "
12½-year-olds (12.0 to 12.9) in grades 5*B* and 6*A* " " " "
13½-year-olds (13.0 to 13.9) in grades 6*B* and 7*A* " " " "
14½-year-olds (14.0 to 14.9) in grades 7*B* and 8*A* " " " "

For example, in the case of the *D* and *E* groups of tests, the data, the procedure and the final standard selected were as follows:

The scores for children 8, 9, 10, 11, 12, 13 and 14 years old (*i. e.,* 8.0 to 8.9, 9.0 to 9.9, etc.) were as in Table VII.

TABLE VII

Frequency of Score Attained in Reading Test: *D* and *E* Combined by the Ordinary School Children Tested

	Frequency for 8-year-old Children in Grade					Frequency for 9-year-old Children in Grade					Frequency for 10-year-old Children in Grade							
Score	*3A*	*3B*	*4A*	*4B*	*5A*	*3A*	*3B*	*4A*	*4B*	*5A*	*3A*	*3B*	*4A*	*4B*	*5A*	*5B*	*6A*	*7A*
40 or less.	6					3	2	3			2	2	3					
41 or less.	1							1				1	1		1			
42 or less.							1											
43 or less.	1												1					
44 or less.	1	1					1											
45 or less.	1												1					
46 or less.	1							1										
47 or less.		1					1	1					1	1				
48 or less.							1							1				
49 or less.		1						1					3	1				
50 or less.							3							1				
51 or less.							4	2							1			
52 or less.	1	1					1					1			2			
53 or less.		1					3						1			1		
54 or less.								1						1		1		
55 or less			1			1	1		1				1			1		
56 or less.							2	1				1	2		1	1		
57 or less.						1	2	2	1						1	1		
58 or less.	1	1						1							2			
59 or less.		1													3	1		
60 or less.						1	1	1			1		1	2	3			
61 or less.	1	1						2						1	1			
62 or less.		2					2	1						2	1			
63 or less.		1					1					1			2			
64 or less.							1	4	2				1	1	4	4		
65 or less.									1	1				2	1			
66 or less.		1			1			1	1	1		1		1	1		1	
67 or less.		4					1						1		1			
68 or less.			1					3	2				1	1	5			2
69 or less.		1	1				1			1				1	1	2		
70 or less.	1		1				1		1						3	1		
71 or less.															1			
72 or less.		1					1	1				1			4	1		
N.	15	18	4	0	1 (38)		30	27	9	3 (69)	3	8	18	17	39	14	1	2 (102)
Median Score ...	43	62	68.5		66		53	58	65	66	40 or less	54	49	62	64	64	66	68

TABLE VII (*Continued*)

	Frequency for 11-year-old Children in Grade										Frequency for 12-year-old Children in Grade											
	3B	*4A*	*4B*	*5A*	*5B*	*6A*	*6B*	*7A*	*7B*		*3A*	*3B*	*4A*	*4B*	*5A*	*5B*	*6A*	*6B*	*7A*	*7B*	*8A*	
40 or less..		2										2	1				1			1		
41 or less..																						
42 or less..																						
43 or less..					1																	
44 or less..																						
45 or less..													2									
46 or less..																						
47 or less..																1						
48 or less..		1														2	1					
49 or less..																1						
50 or less..			1	1	1											1						
51 or less..			1	1	1																	
52 or less..															1	1				1		
53 or less..		1			1								1					1				
54 or less..				1											1							
55 or less..		2			1													1				
56 or less..				2	1	1	1						1		1	1			1	1		
57 or less..					1								1					1				
58 or less..	1	1		1							1					1		1	1	3		
59 or less..	1			2	3	2								1		2				1		
60 or less..		2		1		1		2				1			2	3	2	3		2		
61 or less..						1											2			1		
62 or less..				1	3	1	1									1		3	1	1		
63 or less..				1	3		1								1	1	1			1		
64 or less..			2	2	6	2									2	1	3	1	2	2		
65 or less..				2	1		1								1	1			1	2		
66 or less..				1	1		1											3	1	3		
67 or less..			1	2	2	2		2							1		2	1		3		
68 or less..	1			7	5	2	2								1	3	1	4	1	3		
69 or less..									1				1			1		2		1		
70 or less..					2	2									1	1		2		5	2	
71 or less..						2		1							1		1	1	2	1		
72 or less..	1	1		3	1	3	1	1	1						4	4		5	2	2		
N	4	10	5	28	34	19	8	6	2	(116)	1	3	7	1	17	26	14	29	12	34	2	(146)
Median	4																					
Score	63.5	55	64	65	64	67	65.5	67	70.5		58	low	53	59	65	61	63.5	67	65.5	66	70	

TABLE VII (*Continued*)

	Frequency for 13-year-old Children in Grade											Frequency for 14-year-old Children in Grade								
	3B	*4A*	*4B*	*5A*	*5B*	*6A*	*6B*	*7A*	*7B*	*8A*		*4A*	*4B*	*5A*	*5B*	*6A*	*6B*	*7A*	*7B*	*8A*
40 or less..		1		1	1			1				1							2	
41 or less..																				
42 or less..																				
43 or less..					1			1						1						
44 or less..																				
45 or less..							1	1												
46 or less..																				
47 or less..																		1		
48 or less..		1																		
49 or less..																				
50 or less..																	1			
51 or less..																				
52 or less..																				
53 or less..					1				1						1					
54 or less..							1								2					
55 or less..			1		1		1		2									1		
56 or less..	1				1	1	1		1						1		1	1		
57 or less..									1					1				1	1	2
58 or less..								2	1											
59 or less..								3	3											
60 or less..				1		1		1	2											
61 or less..									2								1			
62 or less..									3	1				2					1	
63 or less..					2	2	2		2										2	1
64 or less..			1	2	2		3		1	1					2			2	2	1
65 or less..				1	1				1								1		2	
66 or less..						1	1		1	1							1	2	2	1
67 or less..					2			2	3	5						1		1	5	
68 or less..					1	2	2	2	7							3	4	1	2	2
69 or less..					3				3					1				1		
70 or less..							3	4	3	1									2	1
71 or less.							1		1										2	2
72 or less..	1			1	5	1	8	6	6	2				1		1	1	1	4	3
N	1	2	2	6	21	8	24	23	44	11	(142)	1	0	6	6	5	10	12	27	13
Median																				
Score	56	45?	59.5	64	67	64.5	69	68	67.5	67		40 or less		62	55	68	67	65	67	68

For 9-year-olds in *3A* the median score was 43.
For 10-year-olds in *3B* and *4A* median score was 51.5.
For 11-year-olds in *4B* and *5A* median score was 65.
For 12-year-olds in *5B* and *6A* median score was 62.5.
For 13-year-olds in *6B* and *7A* median score was 68.
For 14-year-olds in *7B* and *8A* median score was 67.

In consideration of the facts for the other children and of the fact that no nine-year-olds in *2B* were tested, the standards for ordinary children were set as shown in the *DE* column of Table VIII.

TABLE VIII

ESTIMATES OF SCORES ATTAINED IN READING TESTS BY ORDINARY CHILDREN OF EACH AGE: MADE ON THE BASIS OF RECORDS FROM 700 CHILDREN IN A CITY SCHOOL

Age		Test			
Yr.	Mo.	*B+C*	*D+E*	*V+X*	*F*
9	0	52	43	8	?(10 or less)
	1	52	44	8	?(10 or less)
	2	53	44	8	?(10 or less)
	3	54	45	8	?(10 or less)
	4	54	46	9	?(10 or less)
	5	55	47	9	?(10 or less)
	6	55	47	9	?(10 or less)
	7	56	48	9	?(10 or less)
	8	57	48	9	?(10 or less)
	9	58	49	10	?(10 or less)
	10	59	49	10	?(10 or less)
	11	60	50	10	?(10 or less)
10	0	61	50	10	?(10 or less)
	1	62	51	11	?(10 or less)
	2	63	52	11	?(10 or less)
	3	63	52	11	?(10 or less)
	4	63	53	11	?(10 or less)
	5	63	54	12	?(10 or less)
	6	63	54	12	?(10 or less)
	7	63	55	12	?(10 or less)
	8	63	55	13	?(10 or less)
	9	63	55	13	?(10 or less)
	10	63	56	14	?(10 or less)
	11	63	56	14	?(10 or less)
11	0	63	57	15	10 or less
	1	63	57	15	11
	2	63	57	16	12
	3	63	58	16	13
	4	63	58	17	14
	6	63	59	17	15
	5	63	59	17	15
	7	63	60	18	16
	8	63	60	18	17
	9	63	60	18	18
	10	63	60	19	19
	11	63	61	19	20
12	0	63	61	19	20
12	1	63	61	20	21
	2	63	62	20	22
	3	63	62	20	23
	4	63	62	21	24
	5	63	63	21	25
	6	63	63	21	25
	7	63	64	21	25
	8	63	64	21	25
	9	63	64	22	26
	10	63	64	22	26
	11	63	64	22	26
13	0	64	65	22	26
	1	64	65	22	26
	2	64	65	22	27
	3	64	65	23	27
	4	64	66	23	27
	5		66	23	27
	6		66	23	27
	7		66	23	27
	8		66	23	27
	9		66	23	28
	10		66	24	28
	11		66	24	28
14	0		67	24	28
	1		67	24	28
	2		67	24	29
	3		67	25	29
	4		67	25	29
	5		67	25	29
	6		67	25	29
	7		67	25	30
	8		67	25	30
	9		67	26	30
	10		67	26	30
	11		67	26	30
15	0		68	26	30
	1		68	26	30

A pupil who scored under 43 in the *DE* composite was thus rated as of low reading-age in so far forth. A pupil who scored 44 is rated in so far forth as of reading age 9.1; a pupil scoring 45 is rated as of reading age 9.3; and so on. For scores of 64 or better the determination by this test alone is very inexact, since a slight carelessness, cutting his score by 3 or 4, penalizes the pupil by even two or three

TABLE IX

The Facts of Table VIII, Arranged for Convenient Use in Determining "Reading Ages" from Gross Scores in the Reading Tests

B + C		*D + E*		*V + X*		*F*	
Score	Age	Score	Age	Score	Age	Score	Age
51 or less.	Under 9.0	40 or less.	Under 9.0	7 or less.	Under 9.0	9 or less.	?
52	9.1	43	9.0	8	9.1	10	11.0
53	9.2	44	9.1	9	9.5	11	11.1
54	9.3	45	9.3	10	9.9	12	11.2
55	9.5	46	9.4	11	10.2	13	11.3
56	9.6	47	9.5	12	10.5	14	11.4
57	9.7	48	9.6	13	10.7	15	11.5
58	9.8	49	9.8	14	10.9	16	11.6
59	9.8	50	9.9	15	11.1	17	11.7
60	9.9	51	10.1	16	11.2	18	11.8
61	10.0	52	10.2	17	11.4	19	11.9
62	10.1	53	10.3	18	11.7	20	12.0
63	10.3 to 13.0	54	10.5	19	11.9	21	12.1
64	13.0 or over	55	10.7	20	12.2	22	12.2
		56	10.9	21	12.5	23	12.3
		57	11.1	22	13.0	24	12.4
		58	11.3	23	13.5	25	12.5
		59	11.5	24	14.0	26	12.9
		60	11.8	25	14.4	27	13.4
		61	12.0	26	14.9	28	13.9
		62	12.3	27	?	29	14.4
		63	12.5	28	?	30	?
		64	12.8	29	?	31	?
		65	13.1	30	?	32	?
		66	13.6	31	?	33	?
		67	14.5	32	?	34	?
		68	?			35	?
						36	?
						37	?
						38	?
						39	?
						40	?

? = "probably over 15.0, may be much higher."

years of reading age. This is of little consequence in measuring the dependent children, however, since scores of 64 or better were extremely rare in their case. In every case the harder *VX* and *F* series are available for pupils scoring high in the *DE* test; and the *BC* combination score is available for those scoring low in the *DE* test.

Similar data to those of Table VII. were computed for the ordinary children for the *B–C, V–X,* and *F* series. The final result is a table for assigning four reading-age estimates on the basis of the four scores made in *B–C, D–E, V–X,* and *F*. This table (Table VIII.) on page 34 is intended to give values such that if all ordinary children were tested by the methods used for the dependent groups, as many at each age would be above the standard set as below it.

In actual use the facts of Table VIII, are used in the form of Table IX.

From his four scores in *BC, DE, VX,* and *F,* four estimates of reading age are recorded for each dependent child, using Table IX. Thus, for boys *X*, *Y* and *Z* scoring as follows:

Gross Scores

	BC	*DE*	*VX*	*F*
X	18	0	1	0
Y	62	53	11	6
Z	62	52	26	30

We have

Reading Ages by

	BC	*DE*	*VX*	*F*
X ...	Very very low.	Very very low.	Very very low.	?
Y ...	10.1	10.3	10.2	? (under 11.0)
Z ...	10.1	12.3	14.9	? (over 15 probably)

As a single "reading age" each child was assigned that age which seemed most probable from these four separate ages. This single age was sometimes the average of the four, but not as a rule. For the *BC, DE, VX* and *F* tests are of different amounts of significance for different degrees of ability. A child who does well with *F* and *VX,* aging 10.7 and 11.6 for example, should not be brought down because a single omission of a question in the very easy *BC* test brings him down by 4, or to age 9.9, there. This omission or error was probably a mere slip. Again, a child who makes a perfect record in *BC* may be anywhere from reading age 13.0 on. A child who fails entirely with *F* may be anywhere from reading age 10.0 down. For a child of good ability *F* and *VX* are the best indices; for a child of fair ability, *VX* and *DE;* for a child of low ability, *DE* and *BC;* for a child of very low ability, *BC* alone. One of the authors (Thorndike) estimated for each child the "reading age" which seemed the most probable. With the children of low ability all estimates are rough, and at times only a V. L., which may mean anything from 8.5 down, was all that could be stated.

For example for child *X* the estimated total reading age was simply "very very low" (v. l. v.); for child *Y,* it was 10.2; for child *Z,* it was 13.6.

There are many other details concerning methods of scoring the construction, completion and reading tests and estimating the average achievement of ordinary children of each age in these three tests which it would be advisable to present here, were it not for the fact that we expect to improve and extend these tests and to get easier methods of adequate scoring and more exact standards. The reading test, for example, has already been much improved by one of us (see the *Teachers College Record* for September, 1914), and the completion test will be published in a well-graded fully standardized series within a year. Experience is showing that these tests when so improved are of very great value, and the construction tests promise to be of possibly even greater value. For the present purpose it is sufficient to have explained roughly the process by which the dependent and delinquent children are given a construction age, Binet age, completion age and reading age in terms of the achievements of ordinary children, so far as we were able to measure the latter.

One matter, however, may be worth mention in this connection. The critical reader will have noted that there is a difference between the grade taken as ''normal'' for a given age in the case of the reading test and that taken in the case of the completion tests using a different school. In the latter school the children entered school at a younger age or were advanced more rapidly, or both, so that apparently the average 9.5-year-old child there was to be found in grade 3*B* and 4*A*, the average 10½-year-old child in grade 4*B*, the average 11½-year-old child in grade 5*A* and 5*B*, and so on as shown on page 18.

The matter of standards is of course very important in both cases. If we take the nine-year-olds in grades 1, 2, 3, 4 and 5 we shall find for either test a marked rise in ability as we go from grade to grade. Entrance to school and progress in school are due to intellect; and any test of intellect, to be standardized for the average or median child, must be studied in the case of children of average school progress. This however is in part subject to conventions that vary from school to school. The average age of entrance to the schools used by Mr. Trabue in securing standards for the completion test seems to be much below that for New York City at large, for example. If we are misled into using for our standards children in too high grades, our standards will be too high and our ratings of the defendent and delinquent children too low. The reverse holds if we use children in too low grades. It seemed best for Mr. Trabue to use his best judgment and for Mr. Thorndike to do likewise. An authoritative settlement of the standards can come only from the measurement of more ordinary children. The possible effect of these standards being too high or too low will be kept in mind in all conclusions stated in this article. If there are any such errors they are probably such as to make the ''Binet'' ages assigned to the dependent children too high, the ''omitted-word'' ages too low, and the ''reading'' ages too high.

THE RESULTS

So far we have described the tests and the procedure whereby for each test each dependent or delinquent child is rated as at the age at which an average child would make the score which the dependent child made. The results in the form of years and tenths of a year of under- or overageness for each child are given in Table X., columns 6, 7, 8 and 9. The chronological age was determined by the child's statement, corroborated or modified by the records of the institution or county wherever possible. This was not always possible. Of the cases where some more or less official record of age could be had, 59 per cent. agreed with the age as stated by the child himself. The discrepancies were as often up as down, so that the average result from uncorroborated ages may be taken as valid. The records for individuals are subject to wrong inferences where his statement of age is in error, half of the time toward making him seem duller than he is, half of the time toward making him seem brighter than he is. There is reason to believe that the semi-official age is often simply a record of age based on a previous statement by the child. There is also reason to believe that the semi-official record is often in gross error (as when a large boy in a high grade who says he is fourteen is recorded as only seven). Consequently, when we put the mental status of each child in terms of "underageness," we use as his chronological age the average of his own statement and the report of the institution or county-records, or, if the two differ by three years or more, choose the one which best fits his bodily appearance and score in the tests. Since we have entered in Table X. the age by each source of information, anybody who desires can repeat all computations using either age.

Table X. gives also in column 5 each child's average underageness, using the corrected-Binet, completion and reading tests together. This combination of the three into a single measure is justifiable, since the correlations between these three tests are high. In certain cases a median rather than an average is used bcause of the indefiniteness of one of the three measures.

The nature of the commitment was for destitution in the case of individuals 1–50, 81, 100, 101, 107, 108, 109, 112, 114, 115, 116, 122, 123, 124, 126–130, 134, 136–140, 200–275, 277, and 278. In all other cases it was for delinquency.

TABLE X.

THE STATUS OF EACH OF 265 DEPENDENT CHILDREN IN TESTS OF ABSTRACT AND MECHANICAL INTELLECTS. NOS. 1–183 ARE BOYS. NOS. 200–281 ARE GIRLS

(An * before the identification number means commitment by an officer of the court. A question mark in place of the month-figure for an age indicates that the month was not recorded or known by the child, as the case may be.)

Identification Number 1	Age Reported by County Officers 2	Age Reported by Child 3	Age Used in Computing Underageness Estimates 4	Underageness in Three Tests of Abstract Intellect Combined (+ Equals Overageness) 5	Underageness in Mechanical Test (+ Equals Overageness) 6	Underageness in Binet Test 7	Underageness in Completion Test 8	Underageness in Reading Test 9
1	14.2	14.2	14.2	—2.7	—8.7	— .8	—3.5	—3.8
2	12.7			— .1	+2.1	+1.1	— .9	— .6
3	9.7	10.3	10.0	—1.3	+4.5	— .7	—1.7	—2.0
4	13.8			—3.0	—3.0	—3.5	—3.0	—2.6
5	10.4	10.4	10.4	+ .1	—1.5	+ .4	— .5	+ .4
6	10.2	15.8	10.2	—1.1	—2.9	—1.1	— .6	—2.2
7	9.9	9.8	9.8	+ .4	+3.4	— .5	+ .6	—1.0
8	14.?			— .8		—	0	—1.6
9	9.7	9.8	9.8	—1.8	—3.1	—1.7	—	—1.8
10	12.3	12.2	12.2	0	+1.4	—1.7	— .4	+2.2
11	11.2			+1.1	— .8	+1.0	+2.7	— .4
12	14.0			—3.1	—2.2	—3.5	—4.4	—1.5
13	14.3	14.0	14.1	—1.6	+1.1	—1.9	— .6	—1.6
14	12.3			—1.2	+2.3	— .1	—2.7	— .7
15	12.?			—2.7			—2.9	—2.6
16	13.?			+ .2			—1.6	+1.0
17	13.9	13.8	13.8	+1.8	—1.3	+ .8	+ ?	+2.7
18	10.7			—1.6	—1.4	— .4	—2.0	—2.1
19	12.0	13.3	12.7	—2.7	—1.0	—2.4	—3.4	—2.2
20	12.7	12.7	12.7	—1.1	+ .3	— .5	—1.7	—2.2
21	10.3	10.3	10.3	+ .1	+1.3	+ .2	0	0
22	13.6			— .3	+3.4	+ ?	— .8	—1.3
23	9.9			+ .1	+3.5	— .4	— .1	+ .9
24	15.2			— .9	— .4	—1.0	—3.1	+1.3
25	12.8	12.8	12.8	—2.9		—3.0	—2.9	—2.8
26	12.7			—2.4		—1.9	—2.7	—2.6
27	14.?			—3.0			—3.3	—2.5
28	11.5	10.?	11.0	— .3	—3.4	—1.5	+ .9	— .2
29	13.0			—1.8	+3.3	—2.7	—1.4	—1.4
30	13.?			—3.9	—3.1	—3.7	—4.5	—3.4
31	14.3			—2.5			—2.9	—2.2
32	13.9			—3.3			—4.5	—2.1
33	16.6			—3.3	+ .7	—3.8	—3.5	—3.7
34	10.?			—2.1			—2.8	—1.5
35	10.9			— .5	+ .4	— .1	—1.3	0

TABLE X (*Continued*)

Identification Number	Age Reported by County Officers	Age Reported by Child	Age Used in Computing Underageness Estimates	Underageness in Three Tests of Abstract Intellect Combined (+ Equals Overageness)	Underageness in Mechanical Test (+ Equals Overageness)	Underageness in Binet Test	Underageness in Completion Test	Underageness in Reading Test
1	2	3	4	5	6	7	8	9
36	11.3	11.2	11.2	+ .3	— .9	+ .4	— .3	+ .7
37	12.0			+ 1.3	+ 2.3	+ 2.2	+ .8	+ 1.0
38	10.5			— 1.0	— 3.6	— 1.2	— .3	— 1.4
39	9.8			— 1.8	— 1.5	— 1.6	— 2.0	— 1.8
40	9.?	10.?	10.0	— 2.5	— 2.7	— 2.7	— 2.4	— 2.0
41	13.1	13.2	13.2	+ 1.9	— 1.5	+ 1.4	+ 1.1	+ 3.3
42	14.3			— 2.4	— 1.3	— 3.3	— 2.6	— 1.2
43	10.5	10.5	10.5	— .1	— 2.7	0	— 1.0	+ .6
44	12.5	12.4	12.4	— 2.1	— 2.1	— 2.1	— 2.5	— 1.7
45	13.5	14.?	14.0	+ .6	— 1.2	— .6	+ ?	— 1.6
46	14.?			— .4				
47	10.5	10.4	10.4	+ .2	— 2.6	— .2	— .6	+ 1.4
48	13.1	13.2	13.2	— 3.9	— 1.6	— 3.9	— 4.5	— 3.2
49	10.8	10.9	10.9	— 1.5	— 2.2	— 1.4	— 1.8	— 1.3
50	10.3			— 1.2	— .6	— 1.0	— 1.0	— 1.5
*51	15.8			— 6.1	— 1.1	— 5.5	— 6.7	— 6.1
*52	15.1	15.1	15.1	— 3.5	— 1.5	— 2.3	— 5.2	— 3.0
*53	14.3			— 6.0	— 1.8	— 5.9	— 5.8	— 6.3
*54	13.2	13.2	13.2	— 2.0	— 1.0	— .8	— 4.0	— 2.2
*55	12.?			— 2.2			— 2.1	— 2.4
*56	15.1			— 5.5	+ 1.9	— 4.1	— 5.7	— 6.7
*57	14.3			— 2.8	— .7	— 2.3	— 4.2	— 1.7
*58	14.7	14.7	14.7	— .3	— 1.6	— 1.1	— 1.0	+ 1.3
*59	14.2	12.3	13.3	— 4.1	+ .8	— 2.5	— 4.6	— 5.3
*60	16.4	16.0	16.2	— 4.1	+ .6	— 3.4	— 4.8	— 4.0
*61	15.2	15.2	15.3	— 4.2	— .5	— 4.3	— 4.1	— 3.3
*62	16.6	15.6	16.1	— 3.6	— 3.1	— 2.9	— 4.6	— 3.2
*63	13.4	12.4	12.9	— 3.0	— 2.6	— 2.4	— 3.4	— 3.3
*64	13.6			— 4.2	+ 3.6	— 4.5	— 4.6	— 3.5
*65	14.2	14.2	14.2	— 2.4	— 1.5	— 3.2	— 3.0	— 1.1
*66	15.5	15.5	15.5	— 2.4	+ 1.2	— 1.5	— 2.7	— 3.1
*67	14.6	14.7	14.6	— 3.0	— .3	— 2.4	— 3.8	— 2.9
*68	15.7	14.6	15.2	— 4.1	— 4.1	— 4.2	— 4.2	— 3.8
*69	15.4			— 2.1	— 2.5	— 1.4	— 3.6	— 1.4
*70	16.1	14.3	15.2	— 6.1	— 2.5	— 5.7	6.9	5.4
*71	14.3			— 5.4	— 1.6	— 5.7	— 5.7	— 4.7
*72	15.1			— 4.0	— 1.3	— 2.7	— 5.1	— 4.3
*73	13.5	13.4	13.4	— 2.1	— 2.8	— 2.6	— 1.7	— 2.1
*74	15.5			— 4.4	— 4.3	— 4.5	— 4.9	— 3.8
*75	12.4	14.3	13.4	— 2.8	— 1.0	— 1.8	— 3.3	— 3.4

TABLE X (*Continued*)

Identification Number 1	Age Reported by County Officers 2	Age Reported by Child 3	Age Used in Computing Underageness Estimates 4	Underageness in Three Tests of Abstract Intellect Combined (+ Equals Overageness) 5	Underageness in Mechanical Test (+ Equals Overageness) 6	Underageness in Binet Test 7	Underageness in Completion Test 8	Underageness in Reading Test 9
*76	14.5			— .6	+ 2.2	— .3	— 2.0	+ .4
*77	16.3			— 6.2	— 3.6	— 4.7	— 6.5	— 7.3
*78	13.3			— 4.3	+ 3.4	— 3.5	— 5.6	— 3.7
*79	15.4			— 5.9	— 4.2	— 5.4	— 5.4	— 6.9
*80	14.7			— 3.8	— 4.4	— 3.7	— 3.7	— 3.0
81	15.8			— 6.4	— 2.2	— 5.5	— 7.0	— 6.8
*82	15.8			— 4.1	+ 1.7	— 3.6	— 4.4	— 4.4
*83	13.7	13.7	13.7	— 1.7	— 3.1	— .5	— 3.1	— .4
*84	13.7			— 4.5	— 3.6	— 3.9	— 5.0	— 4.5
*85	13.6			— .4	+ 3.4	0	— .3	— .8
*86	15.2	15.2	15.2	— 3.8	— 2.2	— 1.2	— 5.1	— 5.2
*87	14.8	14.7	14.7	— 3.5	— 4.9	— .3	— 4.5	— 5.4
*88	15.0	13.9	14.5	— 5.4	— 2.1	— 5.4	— 6.2	— 5.5
*89	14.1	7.1	14.1	— 3.7	— .3	— 3.8	— 5.4	— 2.0
*90	15.3			— .4	+ 3.2		— 1.9	— .4
*91	16.3	16.3	16.3	— 7.0	— 3.9	— 7.7	— 7.3	— 6.1
*92	12.8	11.0	11.9	— 3.2	— 2.1	— 3.0	— 3.2	— 3.3
*93	14.?			— 5.9			— 5.8	— 6.0
*94	12.?			— 4.2			— 4.0	— 4.5
*95	13.7	12.7	13.2	— 1.3	+ 3.6	— .8	— 2.7	— .5
*96	13.0	13.1	13.1	— .2	+ .5	+ .1	— .6	— .1
*97	13.6	14.3	14.0	— .5	— .7	— 1.2	— 1.4	+ 1.0
*98	16.1			— 3.1	+ .9	— 3.1	— 5.1	— 1.1
*99	10.5	11.0	10.7	— 2.8	— 2.6	— 2.7	— 3.0	— 2.7
100	13.5			— 4.0	— 5.5	— 4.0	— 4.7	— 3.4
101	13.3	13.0	13.1	— .1	+ 1.5	+ .7	— .5	— .4
*102	15.8	15.7	15.7	— 6.7	— 1.4	— 5.9	— 7.2	— 7.1
*103	11.7	11.8	11.8	— .1	+ .4	+ 1.6	— 1.5	— .5
*104	11.1	11.1	11.1	— 2.1	+ .2	— 1.1	— 2.4	— 2.7
*105	12.5	12.9	12.7	— 2.1	— 2.3	— 1.7	— 2.2	— 2.3
*106	10.9	10.8	10.8	— .2	+ 1.7	+ .2	— 1.8	+ 1.0
107	12.3	12.3	12.3	— 2.6	+ 4.3	— 1.8	— 2.8	— 3.3
108	12.6	12.6	12.6	— 2.7	+ 1.0	— 1.0	— 4.0	— 3.0
109	11.0	11.0	11.0	— 1.3	— .8	+ 1.2	— 2.6	— 2.5
*110	13.5	10.1	11.8	— 3.1	— 4.6	— 2.3	— 4.0	— 3.8
*111	11.3			— 2.8	— 5.7	— 2.9	— 3.1	— 2.3
112	10.3			— 1.3	— 3.3	— 1.4	— 1.9	— .6
*113	12.5	11.8	11.8	— 1.2		— 1.8	— 2.6	+ .8
114	8.0			— 1.2	+ 1.1	—	—	—
115	14.0			— 3.9	— 5.2	— 3.7	— 4.2	— 3.7

TABLE X (*Continued*)

Identification Number	Age Reported by County Officers	Age Reported by Child	Age Used in Computing Underageness Estimates	Underageness in Three Tests of Abstract Intellect Combined (+ Equals Overageness)	Underageness in Mechanical Test (+ Equals Overageness)	Underageness in Binet Test	Underageness in Completion Test	Underageness in Reading Test
1	2	3	4	5	6	7	8	9
116	14.2			—4.9	—6.0	—4.9	—5.8	—4.0
*117	13.9			—3.1	—1.7	—2.9	—3.6	—2.7
*118	9.5	9.4	9.4	—2.1	—1.6	—2.1	—	—
*119	11.6	12.8	12.1	—1.1	+ .4	—1.3	—2.3	+ .3
*120	8.1	8.1	8.1	—1.9	— .1	—1.9	—	—
*121	12.3	10.8	11.6	—1.6	+2.2	—1.8	—1.7	—1.4
122	9.3	7.3	7.3	—1.1	+ .4	—1.1	—	—
123	9.7	9.7	9.7	0	—1.9	+ .1	—1.0	+1.0
124	7.0			+1.6	+2.2	+1.6	+1.7	—
*125	10.4	9.3	9.3	—1.0	— .1	— .4	—1.6	—
126	11.7	9.3	10.5	—3.2	—1.3	—2.3	—1.9	—1.7
127	10.5	9.6	10.0	— .6	—1.2	0	—1.5	— .2
128	8.9	8.9	8.9	— .6	—1.7	— .1	— .6	—
129	13.2	14.0	13.6	—3.3	—2.8	—4.1	—4.8	—2.1
130	11.2	10.7	11.0	— .5	—1.8	—1.0	—1.2	+ .8
*131	13.0	11.2	12.1	—3.1	—2.9	—2.8	—4.0	—2.6
*132	10.9	11.1	11.0	—2.5	—5.2	—1.7	—3.3	—
*133	14.1			—3.2	—1.4	—1.7	—4.6	—3.4
134	13.0			—4.2	—4.5	—4.2	—4.6	—3.8
*135	11.5			—1.4	—2.7	—2.0	—2.8	+ .6
136	11.8			— .8	+ .7	— .8	—2.6	+1.1
137	13.3			— .6	+ .5	+ .3	—3.3	+1.1
138	12.5			—4.5	—2.2	—5.0	—4.1	—4.5
139	10.7	10.7	10.7	— .4	+ .2	— .7	—1.2	+ .6
140	14.2	14.2	14.2	—3.3	—2.0	—3.2	—3.3	—3.4
*141	10.2	10.0	10.1	— .5	—2.3	— .6	—2.6	+1.6
*142	12.5	12.5	12.5	—4.6	+1.6	—3.9	—4.6	v.l.
*143	12.5	12.6	12.6	—2.6	—1.2	—2.6	—3.1	—2.1
*144	15.6	15.6	15.6	—4.5	—2.0	—4.0	—6.6	—2.8
*145	9.2	10.2	9.2	—1.7	— .1	—1.2	v.v.l.	v.v.l.
*146	13.5	15.5	15.5	—1.7	—1.7	—1.7	—1.1	—2.2
*147	16.2		16.2	—2.7	—3.0			
*148	16	?	16.2	—6.2	—1.6	—8.7	—8.2	—7.7
*149	15	?	14.2	—8.0	— .6	—8.2	—7.5	v.i.v.
*150	12.7	12.7	12.7	+1.9	+4.2	+1.1	+1.8	+2.7
*151	11.	9.9	10.9	—3.2	—2.4	—3.1	—3.2	v.l.
*152	16.2	16.2	16.2	—2.6	—3.0	?	—3.7	—2.6
*153	11.7	11.7	11.7	—3.4	— .8	—3.9	—2.7	—3.7
*154	13.1	12.1	13.1	—4.3	—1.3	—3.8	—4.6	—4.4
*155	11.9	10.9	11.9	—2.5	— .0	—2.8	—2.7	—2.0

TABLE X (*Continued*)

Identification Number 1	Age Reported by County Officers 2	Age Reported by Child 3	Age Used in Computing Underageness Estimates 4	Underageness in Three Tests of Abstract Intellect Combined (+ Equals Overageness) 5	Underageness in Mechanical Test (+ Equals Overageness) 6	Underageness in Binet Test 7	Underageness in Completion Test 8	Underageness in Reading Test 9
*156	8 +	8 +	8.5	.0	+ 2.4	— .1	— .1	+ .3
*157	10 +	11.0	11.0	— 3.3	— 4.1	— 3.0	— 3.3	v.l.v.
*158	13	12.7?	12.7	— 1.0	— 1.6	— 2.7	— .5	+ .1
*159	14.7	14.7	14.7	— 5.8	— .4	— 4.9	— 6.4	— 6.2
*160	17.2	15.7	16.7	— 6.7	— 3.7	— 7.4	— 7.0	— 5.8
*161	12.		12.2	+ 1.3	+ .8		.8	+ 3.3
*162	15.2	15.2	15.2	— 2.9	+ 1.7	— 2.6	— 4.3	— 1.7
*163	12.3	12.3?	12.3	— 2.9	+ .5	— 1.8	— 3.3	— 3.6
*164	11.3	11.3	11.3	— .7	.0	— .8	— 1.8	+ .4
*165	11.6	11.6	11.6	— 2.6	— 1.0	— 7.6	— 3.6	v.l.
*166	15.3	15.3	15.3	— 7.8	— 7.5	— 7.8	— 7.8	v.l.v.
*167	15.8	15.8	15.8	— 7.0	— 2.8	— 5.0	— 8.1	v.l.
*168	14.0	16.0	15.0	— 3.9	— 1.7	— 2.0	— 4.2	— 5.4
*169	16.9	16.9	16.9	— 4.4	.0	— 4.3	— 3.5	— 5.4
*170	11.9	11.9	11.9	— 4.4	+ .5	— 4.1	— 4.4	v.l.v.
*171	16.3	16.3	16.3	— .8	— 1.7	?	— 1.8	+ .2
*172	16.2	16.2	16.2	— 3.8	— .7	— 3.2	— 4.4	— 3.9
*173	16.1	16.1	16.1	— 4.9	+ 1.0	— 5.1	— 5.6	— 4.0
*174	14.0	14.3	14.3	— 2.4	+ 1.2	— 1.7	— 3.0	— 2.6
*175	11.	10.3	11.3	+ .4	+ 5.4	+ .9	— .8	+ 1.1
*176	9.2	9.2	9.2	+ 1.2	+ .8	+ 1.6	+ 1.0	+ 1.0
*177	15.1	14.1	14.1	— 1.0	+ 1.1	— 2.5	— 2.4	+ 1.8
*178	16	?	16.0	— 9.0	— 4.7	— 7.2	— 8.5	v.l.v.
*179	16		16.2	— 1.5	+ 1.1		— 1.7	— 1.4
*180	13.3	13.3	13.3	— 1.1	+ 2.9	— .7	— 3.2	— 2.4
*181	11.?	10.6	11.6	— 3.0	— 1.0	— 3.4	— 2.8	— 2.8
*182	13.?	13.9	13.9	— 4.0	— 2.4	— 3.6	— 4.1	— 4.3
*183	12.6	12.6	12.6	— 2.6	+ 1.5	— 2.6	— 3.4	— 1.7
200	10.5	10.5	10.5	+ .4	— 1.2	+ .5	— .1	+ .7
201	15.3	15.0	15.2	— 4.1	— 3.8	— 4.9	— 5.8	— 4.5
202	10.?	11.8	11.8	— 1.0	— 2.1	— 1.3	— 1.6	— .0
203	13.8	13.8	13.8	— 1.9	— 2.1	— 2.8	— 2.3	— 1.5
204	10.1	10.3	10.2	— .5	— 1.3	— .9	— .4	— .3
205	11.3	11.0	11.2	— 2.0	— 4.2	— 1.7	— 2.3	— 2.1
206	14.3			— .6	+ .2	+ .3	+ .2	— 2.3
207	12.4	12.0	12.4	— 2.5	— 3.4	— 2.6	— 2.6	— 2.3
208	9.0			— .6	— 3.5	+ .3	— 1.2	— 1.0
209	11.5			— 1.5	— 5.5	— 2.2	— 1.1	— 1.2
210	14.2			— 5.0	— 7.6	— 5.1	— 5.1	— 4.7

TABLE X (*Continued*)

Identification Number 1	Age Reported by County Officers 2	Age Reported by Child 3	Age Used in Computing Underageness Estimates 4	Underageness in Three Tests of Abstract Intellect Combined (+ Equals Overageness) 5	Underageness in Mechanical Test (+ Equals Overageness) 6	Underageness in Binet Test 7	Underageness in Completion Test 8	Underageness in Reading Test 9
211	15.3			—5.8	—3.6	—5.3	—6.3	—5.8
212	12.0			—1.7	—3.0	—1.7	—1.8	—1.6
213	10.6	10.7	10.7	—1.9	—2.7	—1.4	—2.1	—2.2
214	13.0	13.1	13.1	—4.3	—4.8	—4.9	—4.3	—3.8
215	10.?	10.7	10.7	—2.6	—3.1	—2.1	—3.1	—2.7
216	11.1	12.1	11.6	— .6	—4.1	+1.4	—1.4	—2.3
217	13.2			—3.8	— .4	—3.4	—4.0	—4.1
218	9.1			— .5	—2.3	— .7	— .2	— .6
219	9.5	9.4	9.4	— .2	—1.3	— .3	— .3	+ .1
220	11.0	11.0	11.0	— .5	—2.7	— .2	—1.2	— .1
221	13.0			—2.8	—2.5	—2.5	—4.2	—1.7
222	14.9	14.7	14.8	— .1	—1.0	—1.0	0	+ .5
223	9.4	9.4	9.4	+ .7	—1.3	+3.2	— .9	— .2
224	11.2			—2.8	— .2	—2.3	—3.6	—2.7
225	10.?			—2.0			—2.6	—1.5
226	14.4			—2.8	—1.7	—4.4	—3.9	—2.1
227	14.3			+ .2	+ .2	—4.4	—3.9	—1.8
228	12.9	12.9	12.9	—3.2	—3.6	—3.1	—3.0	—2.4
229	8.7	9.9	9.8	— .3	—1.6	+ .7	— .1	— .3
230	10.2			— .8	—3.1	+ .1	—1.2	—1.4
231	12.1	12.1	12.1	+1.4	—3.1	+ .9	+ .8	+2.4
232	11.2	11.2	11.2	—2.9	—5.4	—1.9	—3.5	—3.2
233	8.?			— .6			— .6	— .5
234	11.7	11.8	11.8	—1.2	—4.0	—1.8	— .8	— .9
235	14.5			—3.3	—1.3	—2.3	—4.0	—3.7
236	10.8			—1.7	— .4	—1.5	—2.2	—1.3
237	12.3	11.7	12.0	+1.2	—5.6	+1.0	— .5	+3.0
238	9.0			— .7	+1.5	—1.0		— .5
239	11.8			—2.4	—1.8	—1.5	—3.1	—2.6
240	9.8			+2.8	+1.7	+4.0	+1.1	+3.2
241	10.2			—2.4	—5.2	—2.4	—2.4	—2.2
242	13.4			—1.3	+1.1	—1.2	0	—2.7
243	9.8			+ .4		0	+ .7	+ .4
244	11.9			—3.9	+5.2	—4.1	—3.8	—3.9
245	11.0	11.1	11.1	—3.0	—5.4	—2.9	—2.9	—3.1
246	11.?			+2.3		—	—	+1.1
247	13.?			+1.0		—	—	+ .5
248	11.3	11.3	11.2	+ .2	—3.6	— .5	0	+1.2
249		12.4	12.4	—3.5	— .9	—4.4	—3.1	—3.1
250	9.9	9.9	9.9	+1.5	—1.3	— .6	+2.7	+2.4

TABLE X (*Continued*)

Identification Number 1	Age Reported by County Officers 2	Age Reported by Child 3	Age Used in Computing Underageness Estimates 4	Underageness in Three Tests of Abstract Intellect Combined (+ Equals Overageness) 5	Underageness in Mechanical Test (+ Equals Overageness) 6	Underageness in Binet Test 7	Underageness in Completion Test 8	Underageness in Reading Test 9
251	10.3	10.3	10.3	+ 2.5	+ .8	+ .5	+ 1.8	+ 5.2
252	12.7				— 1.2	+ 1.7	— .4	— 1.4
253	10.3			+ 4.2	+ 1.3	+ 4.3	+ 3.7	+ 4.5
254	12.0			+ 1.3	— 2.7		+ 1.3	+ 1.3
255	13.8			— .6	+ 2.5	— .4	— .2	— 1.3
256	11.7			— .7	— .8	— .1	— 1.2	— .7
257	12.0			— 2.6	— 2.7	— 2.2	— 3.1	— 2.5
258	11.3	14.1	11.3	— 1.0	— 2.7	— .8	— 1.2	— 1.0
259	10.0			— 2.4	— 4.1	— 3.2	— 2.0	— 2.0
260	11.6			— 2.7	— 1.3	— 1.8	— 3.6	— 2.6
261	9.7	12.0	9.7	— .3	— 1.0	— 1.3	— 1.0	+ 1.4
262	10.?							
263	11.7	12.6	12.6	— 3.8	— 6.9	— 4.4	— 3.9	— 3.1
264	13.6			— 3.3	— 4.7	— 3.6	— 4.2	— 2.7
265	11.0	14.0	12.5	— 1.3	— 4.9	— 1.5	— 2.3	— .1
266	12.0			— 3.3	— 2.8	— 2.5	— 3.5	— 4.0
267	12.?			— 3.0			— 3.8	— 3.3
268	12.7			— 4.1	— 3.0	— 4.3	— 4.4	— 3.7
269	10.?	10.1	10.1	— 2.3	— 3.4	— 2.3		— 2.1
270	14.1	13.0	13.6	— 2.8	— 3.2	— 3.1	— 3.8	— 1.6
271	16.?	17.2	16.8	— 6.1	— 5.1	— 5.2	— 8.0	— 6.9
272	11.7	10.7	10.7	— 2.1	+ .8	— 1.6	— 2.6	— 2.2
273	11.6			— 2.7	— 4.0	— 3.0	— 3.2	— 2.0
274	12.3			— 4.8	— 6.5	— 4.8		— 4.3
275	10.5	10.4	10.4	— 1.4	— 3.8	— 1.8	— 1.6	— .8
*276	12.5	12.4	12.4	— 3.1	— 6.6	— 2.4	— 4.0	— 3.4
277	9.?			— 1.5	— 1.9	— 1.1	— 1.9	— 1.5
278	9.9	10.9	10.4	— 1.5	— 2.6	— .6	— 2.3	— 1.8
*279	16.3	11.0	13.7	— 5.1	— 7.2	— 5.1	— 5.1	— 5.2
*280	14.7	12.6	13.7	— 4.5	— 6.8	— 3.7	— 4.8	— 4.9
*281	13.4	11.4	12.4	— 1.3	— 1.8	— 1.8	— 3.0	+ .9

These dependent children as a group are much below ordinary children of corresponding ages in the sort of abilities tested by the Binet, completion and reading tests. They differ of course among themselves. We find one child of much promise, forty-nine of nearly average ability or better, while forty-eight are four years or more behind, and the remaining three fifths are from half a year to four years behind. The nine and ten year old dependents average about seven tenths of a year behind New York City children of the poorer classes; the eleven- and twelve-year-olds average about two years behind; the thirteen and fourteen-year-olds average about two and a half years behind; the fifteen- and sixteen-year-olds average about four and a half years behind.

The variation amongst the dependent children, and their general tendency to be much below ordinary children are shown clearly in Table XI.

TABLE XI

THE NUMBER OF DEPENDENT CHILDREN OF EACH DEGREE OF SUPERIORITY AND INFERIORITY TO THE MEDIAN OF NEW YORK CITY CHILDREN OF POOR NEIGHBORHOODS WHEN MEASURED BY THE BINET, OMITTED-WORD, AND READING TESTS COMBINED. THE SAME FACTS IN PERCENTAGES OF THE NUMBER TESTED OF THE AGE IN QUESTION.

	9 and 10 Years Old[8]		11 and 12 Years Old		13 and 14 Years Old		15 and 16 Years Old	
	No.	%	No.	%	No.	%	No.	%
4 up to 4.5 years above their age...	1	1.8						
3.5 up to 4 years above their age...								
3 up to 3.5 years above their age...								
2.5 up to 3 years above their age...	2	3.6						
2 up to 2.5 years above their age...			1	1.2				
1.5 up to 2 years above their age...	1	1.8	1	1.3	2	2.8		
1 up to 1.5 years above their age...	1	1.8	5	6.2	1	1.4		
.5 up to 1 years above their age...	1	1.8						
0 up to .5 years above their age...	7	12.7	4	5.0	2	2.8		
0 up to .5 years below their age...	8	14.5	4	5.0	7	9.9	1	2.4
.5 up to 1 years below their age...	8	14.5	6	7.5	4	5.6	1	2.5
1. up to 1.5 years below their age...	7	12.7	11	13.7	4	5.6		
1.5 up to 2 years below their age...	9	16.4	3	3.8	4	5.6	2	4.9
2 up to 2.5 years below their age...	3	5.5	17	8.7	5	7.0	2	4.9
2.5 up to 3 years below their age...	4	7.3	18	22.5	7	9.9	3	7.3
3 up to 3.5 years below their age...	2	3.6	12	15.0	11	15.5	2	4.9
3.5 up to 4 years below their age...	1	1.8	3	3.8	7	9.9	4	9.8
4 up to 4.5 years below their age...			3	3.7	7	9.9	8	19.5
4.5 up to 5 years below their age...			2	2.5	3	4.2	2	4.9
5 up to 5.5 years below their age...					4	5.6		
5.5 up to 6 years below their age...					2	2.8	3	7.3
6 up to 6.5 years below their age...					1	1.4	5	12.2
6.5 up to 7 years below their age...							3	7.3
7 up to 7.5 years below their age...							2	4.9
7.5 up to 8 years below their age...							1	2.4
8 up to 8.5 years below their age...							1	2.5
8.5 up to 9 years below their age...								
9 up to 9.5 years below their age...							1	2.4
Number Examined...............	55		80		71		41	
Average Under-ageness...........	.6½		1.8		2.3½		4.6	
Median Under-ageness[9]...........	.8		2.4		2.8		4.2	

[8] Also the three 8-year-olds tested were included.

[9] Medians are calculated from original data, scored in tenths of a year.

In the mechanical test also the dependent children are notably inferior, though not so much so as in the more abstract abilities. On the average they are about one and three fourths years behind. The facts by age-groups are shown in Table XII. This test, involving only thirty minutes of work from a child, does not give an exact measure of an individual; hence, some of the best scores are undoubtedly unduly high and some of the worst, unduly low. The general drift of the measures for the group is, however, entirely reliable.

TABLE XII

THE NUMBER OF DEPENDENT CHILDREN OF EACH DEGREE OF SUPERIORITY AND INFERIORITY TO THE MEDIAN OF NEW YORK CITY CHILDREN OF POOR NEIGHBORHOODS WHEN MEASURED BY THE MECHANICAL TEST. THE SAME FACTS IN PERCENTAGES OF THE NUMBERS TESTED OF THE AGE IN QUESTION.

	9 and 10 Years Old		11 and 12 Years Old		13 and 14 Years Old		15 and 16 Years Old	
	No.	%	No.	%	No.	%	No.	%
5.0 up to 5.5 years above their age...			1	1.4				
4.5 up to 5 years above their age...								
4 up to 4.5 years above their age...			2	2.7				
3.5 up to 4 years above their age...	1	1.9			2	3.2		
3 up to 3.5 years above their age...	1	1.9			4		1	2.4
2.5 up to 3 years above their age...					2	3.2		
2 up to 2.5 years above their age...	1	1.9	4	5.5	1	1.6		
1.5 up to 2 years above their age...	3	5.8	2	2.8	1	1.6	3	7.1
1 up to 1.5 years above their age...	3	5.8	2	2.7	4	6.3	3	7.1
.5 up to 1 years above their age...	3	5.8	2	2.8	2	3.2		
0 up to .5 years above their age...	1	1.9	5	6.8	2	3.2		
0 up to .5 years below their age...	5	9.6	2	2.7	4	6.4	2	4.8
.5 up to 1 years below their age...			6	8.2	1	1.6	6	14.3
1 up to 1.5 years below their age...	10	19.2	6	8.2	8	12.7	3	7.1
1.5 up to 2 years below their age...	7	13.5	4	5.5	8	12.7	5	11.9
2. up to 2.5 years below their age...	4	7.7	5	6.9	5	7.9	2	4.8
2.5 up to 3 years below their age...	7	13.5	8	11.0	3	4.8	3	7.1
3 up to 3.5 years below their age...	2	3.9	5	6.8	4	6.3	3	7.1
3.5 up to 4 years below their age...	3	5.8	2	2.8	1	1.6	5	11.9
4 up to 4.5 years below their age...			5	6.9	1	1.6	3	7.1
4.5 up to 5 years below their age...			2	2.7	3	4.8	1	2.4
5 up to 5.5 years below their age...	1	1.9	4	5.5	1	1.6	1	2.4
5.5 up to 6 years below their age...			3	4.1	1	1.6		
6 up to 6.5 years below their age...					1	1.6		
6.5 up to 7 years below their age...			3	4.1	1	1.6		
7 up to 7.5 years below their age...					1	1.6		
7.5 up to 8 years below their age...					1	1.6	1	2.4
8 up to 8.5 years below their age...								
8.5 up to 9 years below their age...					1	1.6		
Number Examined	52		73		63		43	
Average Under-ageness	1.0		1.8		1.4		1.7	
Median Under-ageness	1.3		2.0		1.6		1.7	

Besides the general inferiority of these children which is so clear from Tables X, XI and XII, as to need no further comment, there is a striking increase in their underageness in abstract intellect as we pass from the younger to the older children. The difference is far too great to be a matter of chance, and requires explanation. It is probably due to a combination of causes.

Consider first of all six children, nine, ten, eleven, twelve, thirteen and fourteen years old respectively, each of whom is next to the dullest child of his age in a thousand. Consider similarly six children, nine, ten, and so on, each of whom is the next to the brightest of a thousand of his age. Consider similarly six, each the hundredth child from the bottom, the 10-percentile child of his age; and six, each the hundredth from the top, the 90-percentile child of his age.

The six, equally dull in the sense of being the 0.1-percentiles or the 10-percentiles for their respective ages, would be unlike in their underageness. The 10-percentile child of nine would be about 1½ years behind in the Binet test for example, while the 10-percentile child of fourteen would be over 3 years behind. In progress at school the 99.5-percentile child of eight might have gained one grade, whereas the equally bright child of fourteen would have gained three. For a child to have gained a year in school obviously means different things according to the time he has had to gain it in. A Binet score of 1½ years behind obviously means one thing in a nine-year-old and something much less objectionable in a fourteen-year-old. The same is essentially true of many achievements.

We should call two children of different ages equally inferior or equally superior if they have the same relative position—are the same percentiles—each for his age. Or, in technical terms, the abilities of children of different ages may be made commensurate by expressing each as a deviation plus or minus from the central tendency for his age and as a multiple of the variability of his age.[10]

The increase in underageness as we go from lower to higher ages in the dependent children is greater than would be expected from the increasing range of individual differences in general as we go from lower to higher ages. As Table XI shows, the percentage of children equal or superior to the average child of the age in question is much less at 15 and 16 than at 8, 9 and 10. There are, that is, selective tendencies sending a relatively duller group of 15- and 16-year-olds than of 8-, 9- and 10-year-olds, to county institutions.

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[10] The original plan of this study provided for measurements of this sort, but it was thought best to use the simpler and more striking underageness as a surer means of making clear the status of these children.

Possible causes for this selection are: (1) the placing-out of brighter children, removing them from the institutions before they get to the high ages; (2) the earning power of the brighter older children whereby they escape commitment after a family catastrophe which would have caused their commitment if they were young;[11] (3) the indirect influence of heredity, since a bright father and mother might in fifteen or twenty years after marriage save enough to offset the father's death or disability, whereas in ten or twelve years they might not; (4) a possible special tendency of children of this sort to fall behind, with advancing years, more than ordinary children of the same initial dulness, as a result of their nature or their training, or of both.

From the point of view of social economy this excess-dulness of the older children means that being a public charge is more and more symptomatic of dulness, the older the child is. Probably the adults up to beyond the prime of life who are public charges would be found to be even duller than these children of fourteen to sixteen.

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[11] Actual full wage earning would be less common than such partial work as would lead a relative to assume the care of a child 15, 14 or even 13, if he or she were capable.

HEREDITY VERSUS ENVIRONMENT AS THE CAUSE OF THE LOW INTELLECTUAL STATUS OF DEPENDENT CHILDREN

It is probable that each reader has explained the facts so far given by hereditary lack of intellectual gifts or by the deprivations of an unfortunate environment, according to his own prepossessions. Ordinarily a certain heredity carries with it a similar environment, so that the amount of force to be ascribed to either can vary almost at the pleasure of the thinker, until a more intimate analysis is made.

We can to some extent get beneath this superficial quarreling about causes in the case of these dependent children. For we can compare the resemblance of siblings who have been almost exclusively subject, pair by pair, to home training with siblings who have been subject for 2½ years or more to the institutional training. If the resemblance between related children were due in large measure to their having been brought up, within pairs, in the same home and, between pairs, in different homes, the resemblance should decrease with length of stay in the institution.

Consider siblings committed in '09, five years before these tests were given, in comparison with siblings committed in 1914, from 0 to 6 months before these tests were given. We have, for example, J. R., W. R. and R. R. committed at the ages of 9.2, 7.3 and 5.4, now 14.3, 12.3 and 10.5 years old, and on the other hand B. F. and C. F. committed only a few months back, now 12.6 and 11.0; and T. T. and J. T. committed only a few months back, now 13.3 and 11.8. If fraternal resemblance were due to home training the R brothers should show very little resemblance, at least in the reading and completion tests, since nearly all their academic training has been irrespective of home influences. The F. and T. brothers should show much greater resemblance.

We have computed the Pearson coefficient of correlation for the siblings committed in 1907 to 1911 inclusive, and for those committed in 1912, 1913 and 1914 up to the time of the tests, both for the tests of abstract intellect and for the mechanical test, using as the deviates to be correlated the measures of Table X.

There are many complicating factors which make these over- and underageness measures far from satisfactory as deviates, and the relation of the selective forces with respect to the two groups is not sure. But as a first rough test of similar parentage versus similar home training as a cause of similarity in intellectual and mechanical achievement, the comparison of these coefficients of correlation for the two groups is instructive. There is very little difference. The fraternal resemblance in the group largely subject to home training is greater in the average score in intellect, but less in the score for mechanical ability. On the average it is only ten per cent. higher for the home-trained group. The averages of the coefficients are .69 and .62 respectively. These gross amounts must not be taken as estimates however of fraternal resemblance in general, as the gross amounts of a coefficient of correlation computed by using as deviates the underageness measures of brothers found in this peculiarly selected group may differ notably from the coefficient computed by using as deviates the plus or minus deviations of individuals from the central tendency for their age and sex expressed as a multiple of the variability for their age and sex.

By using only a part (but a part selected at random so far as this issue is concerned) of our material, we can make a more exact comparison. We can choose, for each pair of siblings long freed from home training, a pair of about the same ages long subject to home training. The two groups of pairs so formed give obviously a much safer means of testing the issue at hand, the disturbing influence of increased variability with age and the like being equalized for the two groups.

We have reported in Table XIII the facts for two groups of nine pairs each, so chosen. The result is substantially the same as before. The home-trained show resemblance within sibling pairs greater in the case of the measure of abstract intellect and less in the case of mechanical ability. The averages of the two correlations are alike (+ .55) in both groups.

It appears that, as far as our data go, equilizing opportunity, as by institutional life for five years or more[12] for children 3 to 9 years at entrance upon it, does not reduce original likenesses within families and differences between families to any notable extent.

This conclusion should, of course, be tested with a larger group of children and also by repeated measurements of the same pairs of siblings. In connection with the experimental results when groups of individuals are given equal amounts of practise, however, and the facts for twins,[13] the facts given here put the burden of proof upon

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[12] Less than this, however, in so far as any of these children have been returned to their homes since the first commitment and then returned to the institutions.

[13] See, for example, the results found by Thorndike, Whitley, Starch, Wells and Kirby—showing that under equal increments of time given to practise individual differences *increase,* and the fact that twins 11 to 14 years old show little greater resemblance than twins 8 to 10 years old.

TABLE XIII

THE STATUS OF 9 PAIRS OF SIBLINGS LITTLE SUBJECT TO HOME TRAINING COMPARED WITH THE STATUS OF 9 PAIRS OF SIBLINGS MUCH SUBJECT TO HOME TRAINING

Date of Commitment	Sex	Identification	Age at Time of Test	Over- or Under-ageness in Tests of Abstract Intellect	Over- or Under-ageness in Tests of Mechanical Intellect	Date of Commitment	Sex	Identification	Age at Time of Test	Over- or Under-ageness in Tests of Abstract Intellect	Over- or Under-ageness in Tests of Mechanical Intellect
June '07	f	J.K.	12.1	+1.4	−3.1	Jan. '14	m	B.F.	12.6	−2.7	+1.0
	m	M.K.	11.0	− .3	−3.4		m	C.F.	11.0	−1.3	− .8
June '08	f	E.D.	11.6	−2.7	−1.3	Sept. '13	f	M.M.	11.8	−2.4	−1.8
	f	L.D.	9.7	− .3	−1.0		f	A.M.	9.0	− .7	+1.5
Oct. '08	f	A.R.	13?	+1.0		July '14	m	W.W.	13.9	−4.0	−2.4
	f	R.R.	11?	+2.3			m	A.W.	11.6	−3.0	−1.0
Nov. '08	m	R.R.	14?	− .4		July '12	f	M.D.	13.1	−4.3	−4.8
	f	N.R.	11.2	+ .2	−3.6		f	M.D.	10.7	−1.9	−2.7
Mar. '09	m	M.K.	14?	−3.0		Mar. '13	m	P.J.	15.1	−4.0	−1.3
	f	Ma.K.	10.2	− .8	−3.1		f	J.J.	12.0	−3.3	−2.8
June '09	f	Ca.R.	10.4	−1.5	−2.6	June '13	f	E.P.	10.4	−1.4	−3.8
	f	Co.R.	9?	−1.5	−1.9		m	R.P.	8.9	− .6	−1.7
July '09	f	M.S.	12.4	−3.5	− .9	Mar. '14	m	W.N.	11.6	−1.6	+2.2
	f	Mi.S.	9.1	+1.5	−1.3		m	G.N.	8.1	−1.9	− .1
July '09	m	R.W.	14.2	−3.3	−2.0	Oct. '13	f	G.G.	14.8	− .1	−1.0
	m	D.W.	10.7	− .4	+ .2		f	Ge.G.	9.4	+ .7	−1.3
Sept. '09	m	E.V.	13.8	− .6	+2.5	Jan. '14	m	T.T.	13.3	− .6	+ .5
	m	K.V.	11.7	− .7	− .8		m	J.T.	11.8	− .8	+ .7
Feb. '10	f	M.B.	12.4	−2.5	−3.4	Feb. '14	f	M.F.	13.2	−3.8	− .4
	f	A.B.	11.3	−2.0	−4.2		f	F.F.	12.3	−1.2	+2.3

those who attribute any great share in the resemblances found in siblings, under the same general conditions of life during the same decade in the same community, to their similarity in home training.

"A Book of Commanding Importance"

Professor John Dewey, of Columbia University, New York, in the July Philosophical Review, writes as follows concerning Mr. Bertrand Russell's recent book **Our Knowledge of the External World as a Field for Scientific Method in Philosophy.**

"There are many ways of stating the problem of the existence of an external world. I shall make that of Mr. Bertrand Russell the basis of my examinations, as it is set forth in his recent book **Our Knowledge of the External World as a Field for Scientific Method in Philosophy.** I do this both because his statement is one recently made in **a book of commanding importance,** and because it seems to me to be a more careful statement than most of those in vogue."

Professor Bernard Bosanquet speaks of the same book, **Our Knowledge of the External World as a Field for Scientific Method in Philosophy,** as follows:

"This book consists of lectures delivered as Lowell Lectures in Boston, in March and April, 1914. **It is so attractive in itself, and its author is so well-known,** that I think by this time it may be 'taken as read,' and I may offer some discussion without a preliminary abstract."

It is admitted by scholars, both in England and America, that Bertrand Russell's book, **Our Knowledge of the External World as a Field for Scientific Method in Philosophy,** is the book of the year.

Note. This book appeared simultaneously in Great Britain and America, brought out by The Open Court Publishing Company of Chicago and London. Unfortunately, by some mistake, the book was published under two titles. In England it is given its full title, while the American edition has the shorter title, **Scientific Method in Philosophy.** The two editions are identical, and it is a little unfortunate that this mistake was made. The second American edition will be brought out under the same title as the English edition.

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THE RELATION OF QUICKNESS OF LEARNING TO RETENTIVENESS

I

BY

DARWIN OLIVER LYON

ARCHIVES OF PSYCHOLOGY

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PREFACE

The present work is the outgrowth of experiments on memory that I have been conducting since the year 1906. My studies have had in view several problems under the general head of memory, and some of the results have already been published as follows:

"The Relation of Length of Material to Time Taken for Learning, and the Optimum Distribution of Time," *Journal of Educational Psychology,* 1914, **5**, 1–9, 85–91, 155–163.

The problem of the present study has been in view from the start, but has not been included, except incidentally, in the articles which are enumerated above.

Acknowledgments are due first of all to Professor Cattell, to whom I am especially indebted for the numerous suggestions and for the many valuable hints and criticisms given me in the treatment of the results. For similar reasons I must also thank Professors Thorndike and Woodworth. To Professor E. Meumann, formerly of the University of Leipzig, I am indebted for his numerous suggestions and for the opportunity given me to perform certain experiments on the students at the University of Leipzig.

The numerous professors, superintendents, principals and teachers who have made this work possible are too numerous to mention. I am under particular obligation, however, to Alfred E. Rejall, formerly professor of philosophy and psychology of the State Normal College at Albany, N. Y.; and also to Mr. Frank Lawrence Glynn, superintendent of the State Trade School of Bridgeport, for numerous courtesies extended me, as well as for his expert opinion on all matters pertaining to vocational instruction.

The author also extends his thanks to the following for permissions and privileges granted: Joseph F. Scott, superintendent of New York State Reformatories and Prisons; Hon. John J. Barry, commissioner of correction of the City of New York; Dr. C. Macfie Campbell, of Bloomingdale Hospital, White Plains; Dr. Frederic L. Wells, of McLean Hospital, Waverley, Mass.; Dr. August Hoch, director of the Psychiatric Institute on Wards Island.

The writer also desires to acknowledge his indebtedness to all those who served as subjects in the various experiments, and especially to those who were so obliging as to undertake the 40-nonsense-syllable, and other long tests.

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THE RELATION OF THE QUICKNESS OF LEARNING TO RETENTIVENESS

CHAPTER I

HISTORICAL

The history of scientific inquiry concerning the relation of The Quickness of Learning to Retentiveness, and, for that matter nearly all experimental work on memory, dates back only thirty-four years. Before 1880, experimental psychology had confined itself largely to reaction times and sensations, but with the publication of Ebbinghaus's "Über das Gedächtnis"[1] in 1885 experimental work on memory acquired an impetus that has ever since been on the increase. The material chosen by Ebbinghaus for his experiments consisted of about 2,300 nonsense-syllables made and selected as follows: From the simple consonants and the eleven German vowels and diphthongs he formed all the meaningless syllables possible by placing a vowel or a diphthong between two consonants. These lists of nonsense-syllables were then shuffled and drawn by lot. Ebbinghaus preferred these "nonsense-syllables" to words because of their relative simplicity. The remark is often made, however, that nonsense-syllables are not simple, and that on the contrary, they are in some respects as complex as words. Ebbinghaus himself remarks that something more simple would be desirable for the reason that the learning of nonsense-syllables involves not only the sense of sight and hearing, but the muscular sense of the vocal organs (tongue, lips, etc.). Moreover, not only do nonsense-syllables *not* possess equivalent tendencies to set up association processes, but certain lists of syllables that may appear equally difficult to one individual, may appear very unequal to another. However, with all their faults, nonsense-syllables are preferred by many psychologists to words, prose, or poetry for testing the "organic memory." Words are apt to form associations too easily, especially with some individuals; and prose and poetry are far from being homogeneous in that they are constantly changing in character. This is especially the case with those individuals in whom

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[1] An excellent translation of this monograph has recently been made by Ruger & Bussenius, under the title "Memory." It comprises Educational Reprint No. 3 of Teachers College, Columbia University.

''interest'' is so necessary that material not ''interesting'' to them is practically impossible of memorization. Though it is true that many of the nonsense-syllables used by Ebbinghaus were such as to allow numerous associations, his experiments were so conducted as to preclude the forming of these associations to a considerable extent; in fact, with Ebbinghaus they were seldom formed. Another advantage in the use of nonsense-syllables is that they afford an almost unlimited number of combinations of a *similar* character and quantity. Nevertheless, nonsense-syllables have so many objections not carried by digits that it is a question as to whether the latter would not be better for the testing of ''organic'' or ''rote'' memory.

Ebbinghaus gave much careful attention to details of method. His method was to repeat the syllables aloud until he could voluntarily recall them. He considered that he ''knew'' them when he was able to repeat the series correctly, in a given time, after the first syllable had been supplied. A series was read through once from beginning to end without stopping, and then upon the first syllable being supplied the attempt was made to repeat the entire series, stopping however, at the first hesitation. At this first hesitation, the remainder of the list was read and the entire repetition was started again. The syllables were read and repeated at the rate of 150 per minute and in a uniform tone. The rate was secured by timing the reading by ticking of a watch or by the strokes of a metronome. Upon a series being completely memorized, Ebbinghaus made a pause of 15 seconds for noting the results, after which he immediately started in on another series. No attempt was made to form logical associations, the speed being so great as to practically preclude this. Ebbinghaus took great care that all the conditions would be such as to favor attention; his environment was such as to favor concentration and in case of ill health the experiment was deferred.

Though Ebbinghaus did not specifically attack the problem of retention as related to speed of learning, some of his results are fundamental in considering this problem. It should be understood that he experimented only upon himself as subject, and that his results have therefore, in the first instance, only individual validity; but it should also be remarked that he tested every point in many trials, and that he was, undoubtedly, an unusually steady and trustworthy subject for experiment.

One of his results that is pertinent to our study concerns the effect on retention of varying amounts of time devoted to the original learning. He found, as we should naturally expect, that the greater the number of repetitions, within certain limits, the better the retention. To determine the effect of many repetitions upon retention he repeated a series of 16 syllables a definite number of times, and then noted how many repetitions were required 24 hours later to complete the learning. He found that about one third of the labor was saved by the repetition of the day before. Thus we may say that three repetitions to-day save one to-morrow, or, in other words, for every three times a person repeats such a list to-day, he will save one repetition 24 hours later. This was true, whether the number of repetitions on the first day was barely sufficient, more than sufficient, or less than sufficient to enable the series to be immediately recited.

In a general way, this same result applied also to the retention of series of differing length, learned at first to the point of correct recitation. As would be expected, it required a longer time to learn a long series than a shorter one. Ebbinghaus found that, as a rule, he could repeat a series of seven syllables after a single reading; about 17 readings were required for a series of twelve syllables, and nearly 30 readings for a series of sixteen. But, on testing twenty-four hours later, he found that the longer series were the better retained. The additional work which the long series demanded in learning produced an enduring effect, much as if it had been devoted to the *over-learning* of shorter series.

Ebbinghaus found that the value of a repetition for purposes of retention was greater when the learning was distributed over several days than when it was concentrated into a single study period. Thus, in one series of experiments, he learned 12-syllable series on one day, and relearned them on the three succeeding days. The average number of readings required for an errorless recitation was 17.5 the first day, 12 the second day, 8.5 the third day and 5 the fourth day. In another experiment he continued reading 12 syllables beyond the time necessary to learn them, *i. e.*, the number of repetitions was greater than that needed for an errorless repetition. Thus if the series was repeated only eight times on one day they were not known the following day; nor could they even be recognized as the list studied. If given 68 repetitions, however, they *could* be recognized the next day, although the series could not be given, for, on relearning the series 24 hours later, 7 repetitions were required. On comparing the two facts as given above it will be noticed that in the first case 38 repetitions, distributed over three days, needed on the fourth day only five repetitions; while 68 readings on one day needed, even on the very next day, seven repetitions.

Ebbinghaus's studies on the rate of forgetting are especially well known. He found that while it is relatively rapid at first, later it goes on more and more slowly, and in his judgment nothing once learned is ever absolutely forgotten. He found after an interval of one hour so much has been forgotten that more than half the time originally expended must be again applied to the work in order to relearn it. After eight hours almost two thirds of the labor must be repeated. From this point it would seem that the process of forgetting proceeds more slowly. After twenty-four hours two thirds of the original labor must still be performed, *i. e.,* the "impression of the whole" retains about one third of its original strength. The change now becomes still slower, for even after six days one quarter is still retained, and after a month one fifth. "It is noteworthy" says Burnham, "that, while the impression made by nonsense-syllables is so evanescent that a series once perfectly learned is forgotten after an interval of twenty minutes, a residuum of some sort persists for a long time, so that even after a month the same series can be relearned in four fifths of the time originally required. A general statement of the results is as follows: The ratio of what is retained to what is forgotten is inversely as the logarithm of the time."

Thus far we have considered only those experiments of Ebbinghaus in which the material used was nonsense syllables.. We will now turn our attention to the experiments in which he used *logical trains of thought.* For this work Ebbinghaus used stanzas from Byron's "Don Juan." He found that the time taken to learn a stanza was only one tenth as long as that needed for a list of nonsense syllables of the same number as the number of syllables in the stanza. In other words, material connected by the bonds of sense and rhythm needed only one tenth the number of repetitions required by material *not* so connected. Not only was the meaningful material more speedily learned, but it was also better retained. As tested twenty-four hours after learning, by his "saving method,"[2] the retention was as follows:

Material Learned	No. Readings Required to Learn	No. Readings Required to Relearn	Per Cent. Retained
12-syllable series	16.5	11	33
24-syllable series	44	22.5	49
36-syllable series	55	23	58
Stanza of "Don Juan"	7.75	3.75	52

Meaning, therefore, affects the speed of learning and the retention in the same way, favoring quick learning and tenacity of retention.

Another factor that affects the two in the same way is the speed of reading. Ebbinghaus reports experiments[3] in memorizing stanzas of Schiller's translation of the Æneid at the rate of 200, 150, 120 and 100 iambics per minute. At these rates, he learned the same number of lines in 138, 148, 160 and 180 seconds respectively, thus proving that the amount of time required varied inversely as the speed of reading.

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[2] See below, p. 20.

[3] Grundzuge der Psychologie," 2d ed., 1911, pp. 672–673.

To be sure, a greater number of repetitions is required with the rapid than with the slow rates. He concludes that the fastest rate of reading is the most economical as concerns the act of learning. In order to test the retention as well, he relearned the stanzas twenty-four hours later, using now for all the constant rate of 150 iambic feet per minute, and found that the stanzas which had been originally read at the greatest speed and learned in the least time were also, on the whole, slightly better retained than those that had been read more slowly. He repeated the retention test after eight days, with the same result.

In 1887 G. E. Müller and F. Schumann,[4] stimulated by the work of Ebbinghaus, set out to repeat his experiments on a more elaborate scale, making, however, certain changes in method and material. Their labors extended over a period of five years (1887–1892 inc.). The only fundamental difference between their experiments and those of Ebbinghaus was that they did not let the subject know the purpose or result of the various experiments, a thing obviously impossible where the experimenter uses himself as subject. The material used consisted of nonsense-syllables similar to those used by Ebbinghaus, but selected with greater care, and instead of being read directly from the sheet of paper on which they were written and where they could all be seen at once, they were read from a revolving drum through a slit in a screen. The drum from which the syllables were read was allowed to revolve at different rates in the various experiments. The three rates used were such that the syllables appeared at intervals of 0.731, 0.615, and 0.572 seconds, respectively. Thus the intervals were so short that no time was given for a second perception or for the formation of mnemonic acids. As explained before, the material used by Ebbinghaus was far from being homogeneous, and had he not read them at so rapid a rate many of his nonsense-syllables would have been highly undesirable because of their easy associations. Müller and Schumann invented a convenient plan for constructing nonsense-syllables of a more homogeneous sort than those used by Ebbinghaus. Ebbinghaus left the make-up of the syllables wholly to chance, while Müller and Schumann laid down certain rules making the series of syllables ''normal'' or ''extra normal.'' A ''normal'' list of syllables had all the initial consonants, all middle vowels, and all final consonants different, respectively, from the syllable immediately preceding or following. The initial consonant of the first, and final consonant of the second syllable in any one of the trochaic feet into which the series was divided in reading, were never the same. Syllables forming well-known words were never allowed to come together. A series of syllables was called "extra normal" when no two syllables used on the same day had two letters the same.

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[4] ''Experimentelle Beiträge zur Untersuchung des Gedächtnisses,'' *Zeitsch. für Psych.*, 1894, **6**, 81, 257.

The most important results of Müller and Schumann's experiments, bearing on the quickness of learning, may be stated as follows:

1. The association between syllables in the same foot is much stronger than that between adjacent members of different feet. The suppression of rhythm in memorizing lists of nonsense-syllables renders the task much more difficult, nearly twice as much time being required.

2. The syllables first learned are not necessarily those presented the earliest. Frequently those syllables at the end of the set are the first the subject is able to reproduce. The syllable first learned is that which first attracts the attention strongly. This may be because certain associations arose easily or it may depend on circumstances purely accidental, *i. e.,* the syllable may have appeared just when the attention was at its "height," and thus the syllable having *gained* the "ascendency," *kept* it, since the attention naturally centered on it every time.

3. The first of any two successively and simultaneously experienced syllables tends to call up the second. If they are associated only through intermediate syllables, the association is stronger if both are accented. The second syllable in a trochaic measure tends to call up the first, and this tendency seems to be stronger than the tendency to call up the first syllable of the next succeeding measure.[5]

4. Under certain conditions, syllables with associations already established prove *more* difficult to memorize in combination with new syllables, than when such associations are lacking. The previous associations press in on consciousness and disturb attention in various ways.

5. The ease of memorizing seems to depend upon the *amount* and *character* of the work that has immediately preceded, aside from the factor of fatigue, which, of course, is all-important.

6. The ease with which series of such syllables are learned depends not alone on the subjective differences, but also on objective conditions, which, however, may *lead* to subjective differences.

Colegrove in his book entitled "Memory" briefly sums up other results of Müller and Schumann's work as follows: A syllable series can be learned more easily (1) if two or more successive syllables have like initial consonants; (2) if two syllables rhyme; (3) if two successive syllables or initial syllables of two successive rhythms have the same vowel or diphthong; (4) if the beginning consonant of the first syllable and the end consonant of the second syllable of a rhythm, or the end consonant of a syllable and the beginning consonant of the next syllable are the same; (5) if two or more syllables form a word. On the other hand, consonants difficult to pronounce or an accumulation of diphthongs impeded the act of memorizing. A series in the trochaic rhythm is memorized more easily than a series in the iambic rhythm.

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[5] We should not, however, infer from this that every presentation *always* tends to call up the one *preceding* but we should take it that when any element of a complex presentation is supplied it tends to call up all the others.

As regards retention, Müller and Schumann found that the person who memorized a series of nonsense-syllables in the shortest time also relearned it in the shortest time after 24 hours. This was to be expected, since what is forgotten can be relearned more quickly by a quick learner than by a slow learner. But the slow learner saved more time, both absolutely and relatively, than the fast learner, when the relearning was compared with the original learning.

Whitehead, in "A Study of Visual and Aural Memory Processes,"[6] sets out to answer the following questions, among others: (1) What is the relative quickness of the visual and the aural senses when employed in the memorizing of nonsense-syllables constructed like those of Müller and Schumann? (2) What is the relative power of retention for matter memorized visually compared with that memorized aurally? Or, put otherwise, what is the relative rate of forgetting for material memorized in the two ways?

Whitehead answers the above questions as follows: "(1) Of our thirteen subjects ten showed themselves able to memorize most rapidly from visual presentations and two from auditory, while one gave ambiguous results. This outcome is without much doubt to be correlated with the fact that so much of our memorizing, whether it occurs in the verbatim form, or merely as the assimilation of meaning, is brought about through *visual process.* (2) Matter memorized aurally appears to be retained slightly *better* than that memorized visually. It requires less repetition by 32 per cent. to learn anew from visual presentations matter memorized visually a week previous, and less repetition by 40 per cent. for aural memorizing of the same kind. The difference is insignificant in view of the total number of cases. It seems to be simply a special case illustrative of the general principle already mentioned that the greater the number of original repetitions the less the number necessary for learning anew."

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[6] *Psych. Rev.*, 1896, **3**, 258.

In regard to individual differences in retentiveness, Whitehead considers that the slow learner both relearns in shorter time and retains a larger amount, than the fast learner. An examination of his results however, does not entirely support this conclusion. As Pyle very correctly says, "If we eliminate the results from one of his subjects (the eleventh in the first table, p. 267) as being an error (for it shows a relearning time longer than the time for original learning), and add the relearning times for the fast six and the slow six, respectively, we find without exception that the six who had learned in the shortest time also relearned in the shortest time. In fact, if we rank the two series for learning and relearning, for the various tables, from the best to poorest, we find a fairly high degree of correlation between quick learning and good retention."

Jost, in his article entitled "Die Assoziationsfestigkeit in ihrer Abhängigkeit von der Verteilung der Wiederholungen,"[7] takes up the distribution of repetitions as a factor of the strength of association. At first he uses the method of "complete memorizing"; then he uses the method of "right associates," and finally the two in conjunction. By the first method he finds that ten readings of a series of nonsense-syllables on each of three successive days make the memorizing of the series on the fourth day easier than do thirty readings on the day immediately preceding, although the difference is small. By the method of right associates he finds that when twenty-four repetitions are distributed equally on three, six and twelve days, respectively, the most extended distribution (that of *two repetitions* a day), gives the best retention.[8] Jost emphasizes especially the matter of repetitions, and explains the value of rests between readings by the theory that the repetition of an older association has a greater value, relatively, than the repetition of a younger one.

In her article entitled "Experimentelle Beiträge zur Lehre vom ökonomischen Lernen,"[9] Miss Lottie Steffens considers the problem of the most "economical" method of learning, more especially for logical trains of thought. The two methods of study which she compares are the "piecemeal" and the "entire" or "mass" methods. The former is that usually adopted spontaneously by a person who has a long passage to learn, and consists in dividing the passage into parts, and reading each part separately till it can be recited, finishing up by a few readings of the whole passage. The "entire" method consists in reading the whole passage through and through till it is learned. The "entire" method, though not appealing to the subject at the outset, is shown experimentally to give the quicker learning, as well as the better retention.

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[7] *Zeitsch. f. Psychol.*, 1897, **14**, 436.

[8] The question naturally arises, however, as to whether some other distribution might not be still more favorable. This problem, viz., the *optimum distribution of time* is considered in greater detail in my article cited in the preface.

[9] *Zeitsch.*, 1900, **22**, 321, 465.

These experiments were repeated by Pentschew,[10] with children as well as adults. He confirmed the advantage of the "entire" over the "piecemeal" method of study in adults, and also in children so far as concerns the learning and retention of meaningful material. With nonsense syllables, however, children did better by the "piecemeal" method, probably because, with children, the learning of nonsense demands so much effort that fatigue and disinclination creep in unless the syllables are studied in small groups.

Ogden, in his paper entitled "Ueber den Einfluss der Geschwindigkeit des lauten Lesens auf das Erlernen und Behalten von sinnlosen und sinnvollen Stoffen,"[11] obtain results much the same as those of Müller and Schumann. He finds that the fast learner rarely requires more time for his relearning than does the slow learner, but usually less. Ogden used both *logical* as well as *nonsense* material and his results were practically the same for both. He found that although the curve of relearning is as a rule nearly parallel to the curve of initial learning, it showed as a rule some flattening, that is, individual differences in time of relearning are not as great as are the differences in time of initial learning.

Henderson[12] found that in general those who learn quickly are able later to recall a greater percentage of what they have learned than the slow learners. In other words he finds that the power to learn readily correlates with the power to remember what has been learned. In his experiments, however, he did not allow his subjects to completely learn the material, and for his material he used only prose. His method, briefly, was as follows: He requested his subjects to read twice a selection taken from "The Dutch Homestead" by Irving. Three minutes was allowed for this. The subjects were then requested to write down as much as they could remember. Two days later they were again called upon to write down as much as possible, and after a lapse of four weeks a third recall was requested. His subjects varied from ten years up. He found that the older subjects learned somewhat better than the younger and explained this as due to their greater capacity to understand. This capacity, however, seemed to have no influence on the relative retention. Henderson's results can not be held to apply to nonsense-syllables or other meaningless material; and even with respect to connected prose, the material used, his results are not directly comparable with those of experiments in which complete memorizing has occurred.

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[10] "Untersuchungen zur Ökonomie und Technik des Lernens," *Arch. f. d. ges. Psychol.*, 1903, 1, 417.

[11] *Archiv. f. d. ges. Psychol.*, 2, 93.

[12] E. N. Henderson, "A Study in Memory," *Psych. Rev. Mon. Sup.*, No. 23, 1903.

Radosavljevich,[13] conducting experiments in Meumann's laboratory upon both adults and children, found better retention for meaningful than for nonsense material, thus confirming the result above quoted from Ebbinghaus. He also confirmed Ebbinghaus's result that long series of nonsense-syllables were better retained than short series, when each had been studied to the point of correct recitation. Practise increased the speed of the first learning and of relearning, but the first more than the second, indicating that memorizing and retention are two distinct facts of memory, possessing their own peculiar laws and conditions. The slower learner showed a greater "saving" in relearning, and he concludes from this that the slow learners retain better than the rapid learners. Adults learn more rapidly than children, but (again according to the "saving" method) retain less of what they have learned; and the younger children, similarly, learn more slowly but retain better than older children.

Extensive experiments upon "The Relation of Facility of Learning to Tenacity of Impression" have been conducted by Miss Gamble since 1908, and are not yet published in full at the date of this writing.[14] Her experiments were designed to answer the following questions:

1. Do the persons who learn with the greater degree of facility retain for a given time the larger fraction of the material severally mastered?
2. In the case of individual subjects, does the rate at which material is presented affect the fraction of the initial learning time which is saved in the relearning?
3. When the learning time is lengthened by the difficulty of the material is the relearning time relatively short or relatively long?
4. How may retention best be gauged?

Two sets of experiments were made: the first set bore only upon the first and fourth of the above questions and was made by the *method of retained members*.[15] The other set, made by the method of complete memorizing (Erlernungsmethode)[16] bore upon all four questions.

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[13] "Das Behalten und Vergessen bei Kindern und Erwachsenen nach experimentellen Untersuchungen," Leipzig, 1907.

[14] The rather brief summary of her work here given has been made from notes taken during the reading of a paper by her at the Washington meeting of the American Association for the Advancement of Science (December, 1911).

[15] This method will be found described below on page 18.

In the first set of experiments Gamble used as subjects 350 college students and as material words, letters and figures. The method of presenting the material and the method of ascertaining each subject's degree of retentiveness differed somewhat from year to year, but the procedure may be roughly outlined as follows: The material was read 4 or 5 times to the subjects and 5 or 6 weeks later was again presented. The subject's tenacity was gauged by the two methods: The first was comparable to what I have called "Method 1,"[17] retention being gauged by the amount of material that could be reproduced without a fresh presentation. The material was then read once to the subjects, after which another reproduction was called for. This is practically the same as what I have called "Method 2,"[18] The material was then read several times to the subjects after which still another reproduction was called for. In some respects, as far as results go, this is very much the same as my "Method 3,"[19] although *complete* relearning was not allowed. On the basis of the results obtained by Method 1, the subjects were arranged in two scales according to their facility in learning and according to their retentiveness as measured by the fraction retained of the amount originally learned. Each scale was divided into quarters. Gamble found that those who fell in the first quartile as regards facility in learning, fell in the first quartile as regards retentiveness in sufficient numbers to show a marked correlation between quickness of learning and tenacity of impression.[20] She recognizes the fact that some subjects who learn a very small amount in the first experiment appear to have retained a relatively large amount, merely because the amount learned the first time was so small that almost anything retained must be a large fraction of it. The results secured by what I have called "Method 2" were of doubtful significance but the results obtained by "Method 3" showed, as might be expected, a marked correlation between facility in learning and relearning.

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[16] This method will be found described on page 2. As used by Gamble, it was practically the same as the method used by Ebbinghaus except that with her the presentations were aural instead of visual.

[17] See below, page 18.

[18] See below, page 19.

[19] See below, page 19.

[20] Were there no correlation whatsoever it is obvious that, by chance alone, about 25 per cent. of those standing in the first quartile of "primary learning" would stand in the first quartile of "retentiveness." As a matter of fact, however, Gamble found that the percentage was about 45,—*i. e.*, 20 per cent. more than chance alone could account for.

In the second set of experiments mentioned above (those made upon subjects by the method of complete-memorizing) facility and tenacity were gauged by the time (in seconds) of learning and relearning. The material consisted of nonsense-syllables. The time which elapsed between learning and relearning was either one or two weeks, differing with different subjects. In these experiments Gamble found a slight correlation between quickness of learning and retentiveness. This, however, she found by what we might term the "absolute" method of comparison, *i. e.*, a comparison of the actual time taken for relearning with the actual time taken for the original learning—not dividing the one into the other and, therefore, not a comparison of percentages. Gamble thus found that, when facility and tenacity are measured on an absolute time basis, those who learn quickly are apt to relearn quickly.

Gamble found that when a series of nonsense-syllables was learned and relearned at the same rate of presentation the fraction of the learning time saved in relearning is greater if the presentation rate is neither very slow nor very fast. When the series are learned at different presentation rates but relearned at the same rate, the fraction of the learning time saved is greater for the series which were originally learned at the slow rate of presentation, unless the absolute learning time of the "slow series" is very small. Series which are hard to learn are more often hard than easy to relearn.

In attempting to answer the question, how retention may best be gauged, Gamble admits that no single method is satisfactory. She objects to a method of reproduction without fresh presentation for the reason that if a long time has elapsed since the series was learned, very many of the subjects can actually reproduce no units whatsoever, although the series may have left subliminal impressions which differ from subject to subject. Though she thinks the method of relearning is valuable to use in conjunction with others, she points out the impossibility of distinguishing the revival of old impressions from a genuine new learning. In the paper here summarized she reached no definite conclusions in regard to the best method of testing retentiveness.

Pyle, in studying "Retention as Related to Repetition,"[21] used for material passages from an elementary book on nature study, containing 40 "ideas" each. Each passage contained on an average 150 words. The subjects taking part in the experiment were twelve graduate and senior college students. Pyle's method of presenting the material to the subjects was as follows:

The experimenter read the material to the subject. After the first reading, the subject gave orally as many ideas as he could recall. The experimenter checked up the record, recording the number of ideas correctly reported. Then the material was read a second time, and a second report was given by the subject and checked up by the experimenter. The experiment was continued in this manner until the subject reported, in his own words, every idea. The experimenter having before him a copy of the material divided off by vertical lines into forty units, found it easy to check up the reports as given orally.

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[21] *Jour. of Ed. Psych.*, 1911, **2**, 311.

After the lapse of 24 hours, the subjects were called upon to reproduce, in writing, as much of the material as possible. The written "ideas" were marked either "right" or "wrong," "ideas" that were partially correct—that is, that had a "kernel" of truth—being marked as correct if they closely approximated the correct idea; rarely, half-credit was given when the variation from the correct meaning was considerable. The material was divided into such small units, each *significant* adjective, adverb or expression being set off as a separate unit, that this point gave little trouble,—a subject either reported the idea or he did not.

The results of Pyle's most extensive set of experiments are shown in the table below. Only four subjects were here used, but each of them memorized 21 passages (of 40 "ideas" each).

Subject	To Learn Repetitions	Av. Dev.	(No. of Ideas) Retention	Av Dev.
C	4.7	2.24	37.5	2.0
F	2.9	0.78	38.5	1.7
K	5.2	1.40	34.2	4.6
J	3.6	1.90	36.7	3.2
Ave.	4.1		36.7	

The results as shown by this table show no great difference in amount retained between the fast learners and the slow learners. What little difference there is would seem to be in favor of the fast learners. It will be noted, however, that we can only say that they retain more *absolutely*. It is possible that had Pyle allowed his subjects to relearn the material previously memorized—obtaining his "amount retained" by dividing the time of second learning by the time of first learning—he might have found that the slow learners, although remembering absolutely less, could *relearn* what they had forgotten in a smaller percentage of their original learning-time than would be required by the fast learners.

By the absolute method, however, Pyle is probably correct in his conclusion that "the slow learner certainly has no advantage in retention over the fast learner." It should be understood, however, that no general conclusions can be drawn from so few subjects, and although in general Pyle's eight other subjects bear out the same conclusion, they do not do so unanimously. However, Pyle's later study[22] of 600 school children shows a high correlation of learning capacity, as measured by immediate memory, with retention, as determined by amount retained 5 weeks later. This extensive study confirms his earlier intensive study, and his conclusions may be stated as follows: A slow learner with more time and repetitions spent in learning does not retain more, absolutely, than the faster learner who uses less time and fewer repetitions.

In 1911, Busemann, in an article entitled "Lernen und Behalten,"[23] published results of several years' work on various aspects of the memory problem. Only a small portion of this work, however, throws light on the relation of quickness of learning to retentiveness. His experiments were performed on school children ranging in age from 12 to 18 years. As material, he used lists of various parts of speech (nouns, adjectives, etc.) and simple syllables. From his results he concludes that of two individuals the one who takes the greater amount of time in memorizing a series of words will require less time, relatively, in relearning them.

In performing his experiments Busemann used two of the various methods described below (page 18), the method of *complete memorization* (Ersparnisverfahren), and the *method of right associates* (Treffermethode). He does not feel that his experiments with the first method can answer the question as to whether the quick learner also forgets quickly. He considers the "Treffermethode" the one to use in answering this question, but does not feel that with this method he performed a sufficient number of experiments to warrant his making any general statement. His results, however, as far as they go, would seem to point against the assumption that it is the quick learners who forget quickly. In summing up his work on this subject he says "it has not yet been proven that a greater ability to learn corresponds to a smaller ability to retain;—on the contrary it is probably true that the good learner is at the same time a good retainer."

Miss Norsworthy, in an article entitled "Acquisition as Related to Retention,"[24] presents some very interesting results. The material she used as well as her method of experimentation were different from any that we have thus far discussed. As subjects she used 83 students in educational psychology. The material used was a German-English vocabulary of 1,200 words. Each student studied twenty minutes for

[22] *Jour. of Ed. Psych.*, 1913, **4**, 61.

[23] *Zeit. für angewandte Psych.*, 1911, **5**, 211.

[24] *Jour. of Ed. Psych.*, 1912, **3**, 214.

five days, memorizing as many of the English equivalents of the German words as possible. Two days were then allowed to elapse, when each student reviewed the list of words that he had succeeded in "memorizing" during the previous five days. Two days more were then allowed to elapse, when the work was again reviewed. At the first meeting of the class after the above three study periods were over, they were asked to write the English equivalents of a certain 50 German words that were presented to them, and that had occurred in the list of German words they had succeeded in previously memorizing. From the results the percentage remembered could then be ascertained. One month after this test, another list of 50 words, chosen from those that remained, was presented to the subject with the request, as before, to write down as many of the English equivalents as possible. In like manner, the percentage remembered of these 50 German words was ascertained.

Norsworthy found that the *average* per cent. remembered in the first test was 63, and that the *average* per cent. remembered in the second test, one month later, was practically the same, being 62. From these averages she found the deviation, either + or —, for each of her 83 subjects. The average deviation from the median for the six subjects learning 700 words or over, was + 14, whereas for the 13 subjects who learned only 300 words or under, the average deviation from the median was — 17. In other words, the quickest learners, who had mastered a vocabulary of over 700 words in a fixed time, retained a larger fraction than the slowest learners were able to retain of their much smaller vocabulary, learned in the same time. With the second test the difference was even more striking. The upper half of the class, in respect to size of vocabulary learned, remembered in the first test, on the average, 70 per cent., the lower half only 52 per cent. The Pearson coefficient, for the whole class, between the number of words learned and the average per cent. remembered is .41 for the first test and .50 for the second test. In short, Norsworthy finds a high positive correlation between rate of learning and retention—a correlation that is considerably higher than that obtained by any of the investigators whose work we have already examined. This, however, is probably due, not only to the method she used—the time remaining constant but the amount learned varying—but also to the nature of her material. This is not meant as a criticism. In fact it is probable that the use of such material as a German-English vocabulary, especially when used in the manner chosen by Norsworthy, is far better, than the use of such material as nonsense-syllables, if we mean by "memory" such memory as occurs in everyday life and especially in the school room.

Norsworthy's method of keeping the time constant, but allowing the amount learned to vary, has numerous advantages. It frees the learner from the responsibility of having to decide when he thinks that the material has been thoroughly memorized—"a responsibility that brings a very varying personal equation into the problem. It also frees the investigator from the burden of making a fair allowance for imperfectly learned material."[25]

In summing up the results of these various investigators, it is perhaps fair to say that they have found *in the main,* and other things being equal, the individuals who learn the quickest to remember the longest, *i. e.,* to be the best retainers. Müller and Schumann found that the quick learners forgot more, but were able to relearn what they had forgotten in a shorter time than the slow learners. An examination of their data shows that, *relatively* speaking, there is not much difference between the quick and the slow learner. Whitehead believes that the slow learner is a better retainer, but from the data he gives it is difficult to see just how he arrives at this conclusion. Norsworthy, on the other hand, obtains a very high positive correlation. Working with a German-English vocabulary she finds that the last quarter of her class retain only two thirds as much as the first quarter. Ogden and Henderson working with meaningful material unite in finding that as a rule the quickest learner is the best retainer. Pyle is somewhat more conservative but says that the fast learner is certainly at no disadvantage in retention.

With most of his subjects, Busemann finds that rapid learning means good retention. Gamble, dividing her classes into halves, quarters, etc., after much the same manner as Norsworthy, obtained in the long run a positive correlation.

In the following pages, which deal with the special research that it is the object of this paper to present, an attempt will be made to prove that on the problem in question no general law or conclusion can be drawn from the use of any single material or method. We will endeavor to prove that not only do different methods give different results, but we shall endeavor to show that *with the same data* it is possible to draw contrary conclusions by dealing with the data in different ways.

[25] *Op. cit.*

CHAPTER II

METHODS EMPLOYED

The Problem Stated

The experiments, which, with their results and the various methods of dealing with same, it is the special object of this paper to discuss, may be briefly stated as consisting in the learning, or "memorizing" of certain materials, allowing a definite number of days to elapse, and then measuring retention by one or more of the methods mentioned later in the chapter. In this way a fairly accurate idea was obtained of each subject's *retentiveness*, and by comparing this with the *time taken* for the initial learning, we arrive at a fairly accurate idea of the relation of each individual's quickness of learning to his retentiveness.

So varied were the materials used and so different the ages, conditions, intellectual standing, etc., of the subjects experimented on, that many results were obtained that have been considered sufficiently valuable to warrant mention although they were not the especial object of the research, and in many cases have no direct relation to the problem. Besides the so-called "normal" subjects, state prison convicts and asylum patients were tested. The latter, over 200 in number, give results so complex in character that they shall be considered only very briefly.

Our results obtained show not only the relation between quickness of learning and retentiveness, but also the relative amount of forgetting after different intervals; the relation between memory for logical trains of thought and for lists of syllables or digits; the effect of age, sex and training on rapidity of learning and remembering; and a comparison of the amount actually retained by each subject with what he can reproduce after one reading.

Methods of Experiment

The main difficulty that one encounters in investigating such a problem as this is to determine which of the various possible methods and materials shall be used. To use all methods and all materials would involve too great a labor for any one experimenter. Three methods were used in this research. Since each method is frequently spoken of and referred to, it was deemed best to give each one some distinctive appellation, and I have named them "Method 1," "Method 2" and "Method 3." Briefly stated these methods are as follows:

Method 1.—Reproduction, as far as possible, of the material originally learned without fresh presentation.

Method 2.—Reproduction, as far as possible after a single presentation.

Method 3.—Supplying the subject with the original material and taking his time for relearning it.

We shall now consider each of these methods in detail.

Method 1.—The subject was given, face downward, a sheet of paper on which were typewritten 20 nonsense-syllables.[1] He was told that he could study these in any way he saw fit, but that as soon as he felt positive he could repeat them without error he should say "now" and come to the experimenter's desk. He was advised not to come up before he felt quite certain that he could repeat them without error, as the time consumed, if he failed to give a perfect reproduction, would be counted as part of his "time for learning." To avoid competition, each subject was taken separately, although where the opportunity presented itself, several subjects were allowed to study in one room, and allowed to come to the adjoining room for their hearing. Instead of reciting his work, each subject was allowed, if he preferred, to write it down.

The question will naturally arise: What was done when the subject came up for examination and made numerous mistakes? To this we can only say that such was seldom the case, it being thoroughly impressed on the subject's mind that he must be sure he could repeat his material perfectly before coming up for his recitation. Where several serious mistakes were made the subject was always sent back to continue his work of memorizing. But where only one or two minor errors were made it was thought best to deduct for these in as fair and scientific a way as possible, rather than send the subject back. This may not seem strictly accurate and scientific, but of two evils it was thought to be the lesser. Otherwise a subject whose time was 15 minutes for the nonsense-syllables might have been 30 minutes had he been sent back to correct the single minor error made.

The material having thus been learned, a definite time interval[2] was allowed to elapse after which each subject was called upon to reproduce in writing as much of the material as possible. It is in this reproduction that we have "Method 1." No especial directions were given for "Method 1," other than requesting that each subject write down as much of the original as he could remember, using the original words whenever he was able. He was also told that where he could remember nothing but the "gist" of the passage,[3] he was to "put that down."

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[1] In explaining these three methods we shall speak only of nonsense syllables. Other materials were also used, as will be explained below.

[2] This varied in the different experiments from 1 day to 10 weeks.

Method 2.—Method 2 was made to follow immediately upon Method 1. The directions read to the subjects for this method were as follows:

"You have just tried to reproduce from memory a set of nonsense-syllables that you learned one week ago. You probably have a fair idea as to the correctness of your paper. I shall now read for you the original set of nonsense-syllables and shall ask you to again write out the list so far as you are able."

This method, that I have designated as "Method 2," is to my mind one of the most satisfactory. Unfortunately it was not used with the first group of subjects (1907–08).

Method 3.—Method 3 was made to follow immediately on Method 2. The directions read to the subjects for this method were as follows:

"You have tried to reproduce in writing a set of 20 nonsense-syllables that you memorized one week ago and which, after one hearing, you just now endeavored to reproduce. You undoubtedly have a fair idea as to the correctness of the paper you just handed me. I shall now supply you with the original set of nonsense-syllables with the request that you relearn them, saying "now" when you feel quite certain that you can reproduce the entire set."

It will be noted, since in "Method 2" the original material is read to the subject, that he does not enter upon "Method 3" with as much ignorance of the material, as if "Method 2" had been omitted. In view of this, in some of the later experiments, a separate series of syllables (or other material) was used for "Method 3," and this, of course, necessitated the memorizing of two distinct sets of syllables in the first place—one for Methods 1 and 2, and another for Method 3.

The writer is aware that these methods are open to criticism. In the first place no one of the three methods is sufficient to answer the problem, and in averaging the results obtained by the three methods, it is a question which method to give the most weight. At the outset of these experiments, Method 3 was considered the most important, and Method 2 was ranked as being *more* important than Method 1. It was later thought, however, that the best way of arriving at each subject's *general retentiveness* was to count each method as equal.

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[3] We are here supposing the material was prose or poetry.

We shall now, taking one method at a time, consider the chief criticisms that may be raised against it.

Method 1.—It has the advantage of getting directly at the matter in hand, *i. e.,* of obtaining from each subject exactly what has been so well retained that it can be voluntarily reproduced after a lapse of a certain period; but it has several disadvantages. The chief of these is that reproduction, without a fresh presentation of the material originally learned, reveals only the strongest of the original impressions—the so-called ''supraliminal associations.'' It can be proved that many of the subjects have a considerable portion of the material once memorized on the ''borderland,'' so to speak,—material that can be entirely recalled after one further reading. Were our investigation merely one dealing with the question of the relation of quickness of learning to *reproductiveness,* we would have to rank Method 1 higher than any other; but where ability to *retain* rather than ability to *reproduce* is the factor in question, it is obvious that we must take into consideration the various associations that are on the ''borderland.''

Method 1 also has the disadvantage of giving results that are difficult of measurement. Very frequently, in an attempted reproduction of material once memorized, the subject (if he is able to recall the various ''topics'' and ''subtopics'' and the ''thought'' of the passage in general) is apt to express this ''thought'' in a greater number of words than existed in the original passage. He is also very apt to introduce new thoughts, thoughts which he may or may not express in words that occurred in the original passage. This introduces several perplexing factors which are difficult of measurement.

Method 2.—Its chief merit lies in the fact that it endeavors to do away with the above criticisms made against Method 1. To this end it endeavors to bring back the ''subliminal'' associations by reading the material once to the subject before asking for the reproduction. This one ''reading'' however, carries with it its own penalty. A single reading of a passage of 100 words consumes about one half minute and it is obvious that one half minute to a quick learner means much more than does one half minute to a slow learner.

The second objection made to Method 1 naturally applies also to Method 2, although not to so great a degree, for this reproduction after hearing the passage read is less likely to contain new thoughts and extra words than if the passage had not been read at all.

Method 3.—In utilizing the results of this method, the plan of Ebbinghaus was followed, the time for relearning being compared with the time of the original learning, and the time saved in relearning, especially the *per cent.* of the original time saved, being taken as the measure of retention, while the time spent in relearning, expressed as a per cent. of the time of the original learning, gives the complementary measure of the "amount forgotten." The chief disadvantage to this method is that, in relearning, it is impossible to distinguish facility in forming fresh associations from retention of subliminal associations. Another disadvantage is that it does not get directly at the amount and nature of the matter retained by each subject. It is thus a serious question if the method is a fair one to use in settling the question in hand. For with this method the subject is not called upon to give exactly *"what he remembers"* at the end of three weeks, but is first given the material to relearn, and *then* asked for a reproduction. A factor is thus introduced that is difficult of measurement, for this "relearning" may recall more to the mind of one subject than another, both of whom might otherwise have given equal results by the first method. It may, however, be justly contended that this factor is desirable since our problem is one dealing with *retentiveness* and not with ability to recall.

Another criticism that may be made against Method 3 is this: it may be said that it is incorrect to rate two men as having the same degree of retentiveness, one of whom takes 25 minutes to learn a passage and three weeks later takes 5 minutes, while the other takes 10 minutes and three weeks later takes only 2 minutes. It may be true that these figures prove both men to have saved four fifths of the time originally spent, and that therefore the amount of the original that each has forgotten is one fifth, but this hardly seems fair, when we consider that the second man takes *only* 2 minutes to do his relearning as against the 5 minutes needed by the first man. Again it is possible that the first man had forgotten the material so completely at the end of three weeks, that not only was he unable to recall any of it, but he also retained practically none of it, and that the second learning was for him practically a memorizing of entirely new material, and that *this* time he took *only* 5 minutes because he was in exceptionally good condition. In fact when the material used consists of digits, we would expect the time for relearning to be, on the average, nearly as great as the original time.[4]

However, taking everything into consideration Method 3 has many merits and gives us information that neither Method 1 nor Method 2 is capable of. It also has the advantage of supplying us with a very easy and accurate measurement, namely, time.

One objection carried by Method 3 is that it takes no allowance for the partial relearning that the preceding methods (1 and 2) have given. Method 3 is supposed to show,[5] besides other things, the actual time that is taken for relearning the material. It is obvious, therefore, that before starting Method 3, the subject should not only not have thought of the material during the period that has elapsed from the day it was originally learned, but he should not be allowed to "review" it just previous to starting Method 3. It is just these things, however, that methods 1 and 2 do—for in the one, the subject endeavors to recall as much of the material as possible, while in the other he is allowed a "review." This, however, is not a criticism against Method 3, *per se,* but a criticism against the way in which the method was here used. Rectification was made in two ways: either (1) a separate and distinct material was used for Method 3, or (2) —the time taken for the reading of the passage (in Method 2) was added to the time given in column 3. [In some cases the time taken for the "attempted reproduction" was also added.] It will be noted, however, in those tables where this has been done, that the addition of a minute or two throughout column 3, makes practically no difference in the final correlation.

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[4] In several cases the second time was not only equal but even greater. This is ascribable either to a poorer mental condition of the subject or to distraction of some sort.

One criticism that might be made of all the methods rather than of any one method in particular, is that an investigation of this subject, to be thorough, should involve the use of various time intervals. For example, instead of merely allowing 10 weeks to elapse between the time of *initial learning* and time of *relearning,* we should also use intervals of one day, one week, six months, etc. Proof that the length of the time intervals allowed to elapse should be seriously considered is seen in the fact that with most groups of subjects the correlation of quickness of learning with retentiveness depends partly on the length of the time interval.

The complete solution of a problem of this nature should take into consideration all the mental performances of the subject, and should involve the use of all the senses, since each one may be said to have its own "memories." Limited experiments, such as these herein described, can answer the question only in a limited degree.

MATERIALS USED

Five main kinds of material were employed on all of the regular subjects. Some of these were omitted or abbreviated in the case of the insane.

The chief materials were digits, nonsense-syllables, words, prose and poetry. Four sets of each of these were employed. The specifications of the materials chosen, and their method of selection, are described below under their respective headings.

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[5] See column 3 of any of the tables.

(*a*) *Digits.*—In the regular set of experiments the number of digits used was 20. With one group of 16 individuals, series of 40 were also used. The method of procedure in making the list of digits was as follows:

Small cards, bearing the digits from 0 to 9 inclusive, were placed in a box and shaken up. They were then taken out, one at a time, and if the digit drawn violated none of the rules given below, it was written down as one of the list. In any case before drawing another digit, the digit previously drawn was put back in the box and the box shaken.

Rules:

1. The digits must be drawn by chance.
2. No digit may be allowed to follow another that is one half as much, or twice as much, as the first, *e. g.*, 6 may not follow 3, nor 3 follow 6.
3. No digit may follow another that is only one more or one less than the digit in question, *e. g.*, 4 may not follow 3 nor 3 follow 4.
4. No three digits may be allowed to come together that have the same difference between them, *e. g.*, 3–5–7.
5. No two digits may come together that have already appeared together in the list.
6. Since digits, like nonsense-syllables, words, etc., are generally learned rhythmically in groups of four, no digit may start a group that had previously been used to start a similar group, nor may the final digit of a group (of four) be permitted to stand if it has already been the final digit of a preceding group (of four), *e. g.*, if 7–1–5–2 have occurred once as one group, no other group in the same series may start with 7 or end with 2.

(*b*) *Nonsense-syllables.*—The diverse results that have been obtained by different experimenters using nonsense-syllables as material can be partly explained by the difference in the syllables selected, *i. e.*, their degree of "nonsensity." The nonsense syllables employed by Ebbinghaus should hardly be called by this name as many of them are, in German as well as English, practically words. Those used by Müller and Schumann were selected with greater care and are on the whole much better. A really good set of nonsense-syllables is extremely difficult of formation. My own method of making the series of 12 and 20 was as follows:

Out of a list of 90 nonsense-syllables,[6] three competent judges selected forty-five that to their minds "carried the fewest objections." These forty-five were then placed in a box and, by following certain rules similar to those laid down for digits, three sets of 20 were selected. Here, as with the digits, if the syllable drawn violated any of the following rules, it was thrown back and another selected in its place.

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[6] There are only about 90 fairly good nonsense syllables for English-speaking persons.

The rules observed in the arrangement of the nonsense-syllables were as follows:

1. Syllables must be drawn by "chance."
2. Initial consonants may not be the same unless separated by two or more syllables.
3. End consonants may not be the same unless separated by two or more syllables.
4. Vowels may not be the same unless separated by two or more syllables.
5. The initial consonant of one syllable may not be the same as the final consonant of the preceding syllable.
6. There may be no repetition of the same syllable in any one series.

(*c*) *Words.*—In the regular experiments only nouns were used. These were drawn by chance from 200, previously selected, and arranged in lists of 20. Whenever the word drawn, made, with the preceding word, an association that was considered "quite obvious" by two of the three judges, the word was thrown back. Of the four sets of words used, two were formed entirely of words of three letters.

(*d*) *Prose.*—Several passages of different nature and content were chosen, as follows:

1. A passage of 100 words from Kipling's "Kim" starting with "The diamond bright dawn."
2. A passage of 100 words from the preface of Haeckel's "Riddle of the Universe," starting with "The present study."
3. A passage of 100 words from Kant's "Critique," beginning with "Time is nothing but the form of the internal sense."
4. A passage of 100 words from Franklin's "Autobiography," beginning with "But I soon found."
5. Two sets of unconnected sentences, each set comprising in all 100 words.

(*e*) *Poetry.*—Two selections, each containing four stanzas of four lines.

METHODS OF SCORING

The method of scoring the various reproductions of the material memorized—a matter of prime importance in an investigation of this nature—will now be considered in detail.

(*a*) *Digits.*—Method 3 needs no comment as to scoring. It is obvious that where complete relearning is used, the only measurement we have to consider is that of time. In methods 1 and 2, however, we must take into consideration the various mistakes, be they of omission, insertion of wrong material, or wrong order. In my earliest experiments, I used the method devised by Ebbinghaus,[7] scoring every omission as one error, every displacement from the correct position in the series by two or three places as 0.5 error, and every displacement by four or more places as one error. The subjects were then compared with respect to their error-score in series of each length separately. I found however, upon correlating the scores thus obtained, that my results were practically the same as when using the much simpler method used by Dr. Whitley.[8] "The chief difficulty," says Whitley, "in comparing people's work on memory, lies in the variable methods of scoring, especially with regard to transpositions. If the order is 76431528 and a subject writes 7463 . . ., some experimenters call it two errors because both the 4 and the 6 are in the wrong place; other experimenters call it one error because by making one change—by 'lifting' the 6 over the 4, it is corrected. The latter method seems preferable. Supposing a subject were to write 87643152, eight errors would be scored by the first method since each numeral is misplaced; by the latter method only one error is scored, since one change would set all right." Thus a misplacement is rated by Whitley practically the same as an omission. For example, a subject writing 76–31528, would, by the first method, be scored one error for omitting the 4, but two errors if he placed it before the 6. By Whitley's method, however, he is, by counting misplacements and omissions as equal, scored only one error. This method as used by Whitley is the method that was used in scoring the results given in the following tables. Each numeral that was given correctly was scored 1, and if it was in the right place—either relative or absolute,[9] it was scored 1 more. This method may at first sight seen crude, but many were tried and the more elaborate ones were discarded.

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[7] H. Ebbinghaus, "Ueber eine neue Methode zur Prüfung geistiger Fähigkeiten und ihre Anwendung bei Schulkindern," in Z. P., 1907, **13**, 401–457.

[8] "Tests for Individual Differences," *Archives of Psychol.*, 1911, No. 19.

[9] I counted a digit to be correct as to its *relative position* provided it was preceded by the correct digit. My reasons for using the *preceding* digit instead of the *following* digit in determining correctness of position are given in the following sub-section entitled "Nonsense Syllables." If in place of a digit the subject merely drew a line thus indicating that he was aware of an omission, he was given credit for thus preserving accuracy of position for the digit following.

Examples of the Scoring of Series of Digits are Shown Below

Series studied	5	0	9	4	7	1	5	2	6	3	8	0	4	7	3	8	1	6	2	9		
Reprod. by subj. A. F...	5	0	9	4	7	–	5	3	8	0	4	7	3	6	2	9						
Score	*2*	*2*	*2*	*2*	*2*		*2*	*1*	*2*	*2*	*2*	*2*	*2*	*1*	*2*	*2*						Total *28*
Reprod. by subj. J. M...	5	0	9	4	7	1	5	4	3	6	8	0	2	5	9	6	4	6	1	2	9	
Score	*2*	*2*	*2*	*2*	*2*	*2*	*2*		*1*	*1*	*2*	*2*						*1*	*1*	*2*	*2*	Total *26*
Reprod. by subj. M. K..	5	0	9	4	7	1	5	2	6	3	8	0	7	–	3	8	1	6	2	9		
Score	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*1*		*2*	*2*	*2*	*2*	*2*	*2*		Total *37*

(*b*) *Nonsense-syllables.*—With nonsense-syllables also, Method 3 gives no difficulty as far as scoring is concerned, but with Methods 1 and 2 we encounter the same difficulties that confront us with digits, since omissions and misplacements are usually numerous. Here also I first tried several of the more elaborate methods including that of Ebbinghaus, but discarded them for one of my own make. This method, while easy and quick, proved, upon comparison with the results obtained by the more elaborate method, to be fully as accurate. Briefly stated the method is as follows: Each correct letter, provided the syllable is in the *correct position*,[10] receives a score of 1, and the syllable, for being in the correct position, receives an extra score of 1. Thus a perfect syllable in the correct position receives a score of 4. A syllable correct in itself, but not correct in position, receives a score of only 3. If the position is correct, and the syllable has two of the three letters correct[11] it is scored 3. If two of the three letters of the syllable are correct but the *position* of the syllable itself is not correct, either relative or absolute, it receives no score at all. Therefore, unless position is correct, the separate letters do not count unless *all* are correct.[12] It must be remembered that, as before said, if a syllable is correct, but is not in the correct position, it gets 3 and only 3 counts, since each syllable that is in the correct position and also correct in itself receives a count of 4. The highest score, therefore, obtainable for a list of 20 syllables is 80.

The subjects were told to draw a line under the last syllable in their reproduction if they felt sure that it *was* the last syllable. In this way the last syllable, even if it was not preceded by the correct syllable, was counted as being in the right position and given a score of 4 if it was correct and underlined. It was given a score of 4 since it had the correct absolute position.

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[10] "Correct position" here, as with digits, may mean correct *relative* position or correct *absolute* position. A syllable is in the correct relative position when it is preceded by the correct syllable, or by a syllable of which two letters are correct, provided these letters themselves be in the right order.

[11] Provided these two letters themselves are in the correct order.

[12] When, however, all three letters are written, but not in correct order, *e. g.*, the letters reversed,—the syllable receives a score of 1, but if the *position* also is correct, a score of two.

The method of scoring is illustrated by the following example.

List of Syllables Studied	Reproduction by Subject J. M.	Scores
VUS	VUS	4
YIF	VIF	3
MIV	JEP	3
JEP	RIL	
VOB	BOV	2
FEG	SIR	
WOF	WOL	3
TIB	TID	3
NUZ		
BOF		
JED		
KIB		
VEL		
ZID		
BOL		
SEF		
YAB		
KUV		
TEF		
NAD		
		Total score 18

In explanation of this scoring, the following remarks may be added. *VUS* get 4 counts, being correct in everything. *VIF* gets only three counts, since although its position is correct, it starts with "V" instead of "Y." *JEP* gets 3 counts; had it been in the correct position it would have gotten 4, since, when a syllable is correct as to its letters, but in the wrong position it is credited with only 3 counts,—one for each letter. *RIL* receives no score at all, there being no such syllable. *BOV* receives a score of 2, for it contains all the letters that occur in *VOB* and, moreover, is in the correct position, *i. e.,* where *VOB* should be. *SIR* receives no score at all. It is quite likely a pure guess, and put down merely to secure correctness of position for the two following syllables. We are all the more led to believe this when we perceive that the next two syllables, *WOL* and *TID,* have, in each, two letters correct,—their positions also being correct.

(*c*) *Words.*—With words, method 3 also gives no difficulty, time being the only measurement. With methods 1 and 2, however, a method similar to that used with nonsense-syllables was employed. A score of 1 was given if the position, whether relative or absolute, was correct. Here also correctness of the relative position was determined by the preceding word. An extra count was given if any two letters[13] were correct, provided that the position of the word was correct. If the word was wholly correct it received still an extra count, making a maximum of 3 counts for each word.

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[13] The same rule was used here as in the case of the nonsense syllables and the two letters themselves had to be in the correct order.

The scoring is illustrated by the following case:

Series of Words Studied	Reproduction by Subject M. K.	Score
TUB	TUB	3
PIN	HEN	2
HEN	JUG	2
BED	RAT	
LID	TAN	
GEM	MUG	
BUD	CAT	2
CAR	RUG	2
MAT	PEN	2
ROD	BED	3
JUG	GUN	3
FOG		
LAD		
SOD		
PEN		
CAT		
RAG		
BOX		
NET		
GUN		
		Total score 19

This scoring may be elucidated by the following remarks. The first word *TUB* is given 3 counts, it having two letters correct, it also being the correct word and also being in the correct position. *HEN* is given a score of 2, it being the correct word but not in the correct position. For like reasons *JUG* is scored 2. *RAT* receives no score at all, although it has two letters, "*–AT*," that are correct (they being also in the word *CAT*). The word however is not in the proper position either relative or absolute and hence can receive no count at all. Words of this kind therefore receive a score of 2 or nothing for reasons given in detail under nonsense-syllables. The fairness of this rule is made clear when we realize that had the word *RAT* been preceded by the word *PEN,* the chances of *RAT* having been a mere guess would be greatly lessened. *TAN* receives no count at all. To the next word *MUG,* one is tempted to give a score of 1 since it contains the two letters *UG* which are also contained in *JUG.* It would have received credit for these two letters had the word been preceded by *ROD.* Not being preceded by *ROD* it is given no count at all. That this is perfectly fair is in this particular case very conveniently shown by the appearance later on of the word *RUG,* which, although there is no such word, is given a score of 2, it being preceded by the correct word *CAT*. The two letters that are correct in this case are *R–G* and although separated by the wrong vowel ''U'' they are in the proper order. *PEN* receives a score of two, it having two letters correct and also being the correct word itself. *BED* receives a score of 3, 1 because it contains two correct letters, 1 because it is the correct word itself, and 1 because it is preceded by the correct word. In this case the ''preceding'' word is not wholly correct but it contains two correct letters and this naturally gives *BED* a higher scoring than it would have received had it been preceded by the word *AXE,* for example. The last word *GUN* receives a score of 3, it being in the correct absolute position for the reason that it is underlined, this proving that the subject knew it was the last word.

(*d*) *Prose.*—The simplest method of scoring the prose passages is to grade the papers offhand on a basis of 10 (or 100) equaling perfection. With this method, however, some examiners would not consider that ''perfection'' necessarily required the use of the identical words occurring in the original, nor might they consider that it required a perfectly correct order of these words. With a certain amount of justification, they might say that the only thing necessary to get a score of 100 would be to have a perfect reproduction of the various ideas contained in the original passage,—in other words, a practically perfect impression of the ''content'' of the passage. This rather rough method of scoring has been used by several experimenters. I used this method for a time, but soon gave it up for the more exact method of Henderson,[14] somewhat modified.

In scoring, Henderson divided his prose passages into ''topics,'' ''sub-topics,'' ''details,'' and words. He was thus able to score his papers according to the number of ''ideas'' and ''parts of ideas'' that were retained. We shall first take up his method of scoring the smallest of the subdivisions, viz., *words,* and this is best given in a quotation from Henderson himself: ''The scoring of words remembered might easily become a complicated matter. Doubtless, the reproducing of certain words means far more power of memory than that of others. I have used the following system. All words of the original that were reproduced in their former contexts were scored full value. Commonplace words, particularly articles, prepositions, and conjunctions, were not scored when reproduced out of their context. On the other hand, an unusual word was regarded as remembered, even though it appeared in the wrong context. Occasionally a word was evidently used because its sound was somewhat like that of one in the original. A half credit was here given. Words that were modified to suit changes in construction, etc., were given partial credit also.''

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[14] E. N. Henderson, ''A Study of Memory for Connected Trains of Thought,'' *Psy. Rev. Monog. Supp.*, No. 23, 1903.

In defending his method of analyzing a passage into the various divisions mentioned, Henderson says:[15] ''It must be confessed that this analysis has in it something arbitrary. To say that each of the detailed thoughts thus indicated is equal in value to every other is manifestly absurd. And this is true whether our estimate be based on relative importance to the thought in general or on relative difficulty of recall. But it must be granted that the same objection could be raised against any endeavor to compare two mental conditions quantitatively. However, as the mind of the subject traveled over the thought it was trying to reproduce, it may be conceived to have rested momentarily on each of the details indicated. In general, the better memories could be expected to retain not only the easily remembered details, but also the ones harder to recall, whereas the poorer ones would retain only the former class. In such cases the scores given can not be challenged on the ground that the lack of equality between the units renders the ranking of the subjects arbitrary. Placing different values on the ideas or analyzing the units differently might affect the ranking in cases where the loss of certain ideas is pitted against that of different ones, but seldom, I am confident, could one justify a valuation or an analysis so different from mine as to affect materially the ranking of a student. Hence, the general results of my investigation are, I conceive, not dependent on the peculiarities of my scoring.

''The scores given have not been diminished, because of errors. They are records only of what was retained. I have taken the ground that the erroneous idea that contains the suggestion of the true one deserves a positive rather than a negative score. It indicates a thought corresponding, however inaccurately, to the earlier one. Such ideas are given a part of the value of an accurate memory. Some individuals, it is true, leave unexpressed the hazy idea that they fear is erroneous. They might suffer by comparison with cloudier minds that failed to discover the presence of the fog. However, a mind that feels a certain idea to be inaccurate is usually able to express the part or phase of the thought that is accurate, and thus render a true account of what was in the memory.''

My own method of scoring is really nothing but a modification of Henderson's. The papers were first marked on a scale of 100 by three competent judges. The average of these marks was then taken and called ''Judges' Mark.'' The papers were then scored by Henderson's method, the score, however, being converted into a scale of

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[15] *Op. cit.*, p. 33.

1–100. This was termed "Henderson's mark." The *arithmetical mean* of these two "marks" was then taken as the final score. It was seldom that the two methods of scoring differed by more than 3. In one or two instances the difference was as great as 5, though this difference was mostly due to the presence of an introspective postscript that had been added by the subject, and which, while it could not be considered in Henderson's method, was evidently considered by the judges. It was frequently clear that the subject had a fair idea of certain "thoughts" that he was unable to express,—thoughts that were evidently not expressed in words sufficiently correct to obtain, by Henderson's method, as high a score as the judges deemed them worthy of,—for in these cases the "Judges' Mark" was invariably higher than "Henderson's mark."

The results of this method of scoring can be seen in the following examples.

PASSAGE STUDIED.

The diamond-bright dawn woke men and cows and bullocks together. Kim sat up and yawned, shook himself, and thrilled with delight. This was seeing the world in real truth, this was life as he would have it—bustling and shouting, the buckling of belts, and beating of bullocks and creaking of wheels, lighting of fires and cooking of food, and new sights at every turn of the approving eye. The morning mist swept off in a whirl of silver; the parrots shot away to some distant river in shrieking green hosts: all the well wheels within earshot were at work.

REPRODUCTION BY SUBJECT A. F.

The diamond bright dawn woke men and cows and bullocks together. Kim awoke, sat up, yawned and shook himself. This was life as it should be, this was seeing the world in real truth. The creaking of wheels, the lowing of cattle, the clanking of chains, the ringing of bells and new sights at every turn of the approving eye. The parrots shot off to some far away river in shrieking green hosts; the ———————————— and all the well wheels of industry were at work.

Score, 72.

REPRODUCTION BY SUBJECT J. M.

The diamond bright dawn woke men, and cows and bullocks all together. Kim sat up and yawned, shook himself, and thrilled with delight. This was seeing life in real truth; this was life as he would have it. The blowing of horns, the lowing of cattle, the cracking of whips, and the creaking of wheels.

(There was also something about parrots flying across the river, . . . and that everybody was at work.)

Score, 49.

REPRODUCTION BY SUBJECT M. K.

The diamond bright dawn woke men, and ——, and bullocks together. Kim awoke and sat up. "This was seeing the world in truth, this was life as he would have it." The buckling of belts, beating of bullocks and blowing of horns, the cracking of fire and cooking of food and new sights at every turn of the approving eye.

Score, 50.

(*e*) *Poetry.*—The scoring of the poetry was practically identical with the scoring of the prose. Nothing, therefore, need be said unless it is that the "judges' mark" was more or less influenced by the quality of the rhythm, rhyme, etc. For example, other things being equal, a word that rhymed with the appropriate preceding word was given preference over one that did not, even though neither of the words appeared in the original stanza.

The result of the scoring is seen in the following examples:

SELECTION STUDIED[16]

And gentle Ellen welcomed her
  With courteous looks and mild:
Thought she "what if her heart should melt,
  And all be reconciled!"

The day was scarcely like a day—
  The clouds were black outright:
And many a night, with half a moon
  I've seen the church more light.

The wind was wild; against the glass
  The rain did beat and bicker;
The church-tower swinging over head,
  You scarce could hear the Vicar!

And then and there the mother knelt,
  And audibly she cried—
Oh! may a clinging curse consume
  This woman by my side!

REPRODUCTION BY SUBJECT A. F.

And gentle Ellen welcomed her,
  With tender looks and mild.
Thought she, "what if her heart should melt
  And all be reconciled."

The day was scarcely like a day,
  The clouds were black outright
And many a night with half a moon
  I've seen the church more bright.

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[16] Other selections of prose and poetry, and other lists of digits, words and nonsense syllables, used as materials with some groups of subjects, are reproduced in the Appendix.

The ——————————————,
——————————————;
The church tower swinging overhead
You scarce could hear the preacher.

And then and there the mother knelt,
and audibly she cried,
"Oh, may a clinging curse consume,
This woman by my side!"

Score, 85.

REPRODUCTION BY SUBJECT J. M.

And gentle Ellen welcomed her
With courteous looks and mild,
Thot she, what if her heart should ——,
And all be reconciled.

The sky was dark, the wind blew wild,
——— ——— ——— ———
We scarce could hear the vicar.

(There was something about a mother praying that another woman be cursed.)

Score, 39.

REPRODUCTION BY SUBJECT M. K.

And genter Ellen welcomed her,
With courteous looks and mild,
Tho't she what tho her ————
——————————————.

The day was ————
The clouds ——————————
And many a night I seen more

Score, 23.

CLASSES OF SUBJECTS TESTED

1. 40 grammar-school students. Modal age, 14.
2. 24 trade-school students. Modal age, 16.
3. 60 high-school students. Modal age, 17.
4. 24 state reformatory inmates. Modal age, 20.
5. 132 normal-college students. Modal age, 21.
6. 32 Columbia College seniors. Modal age, 22.
7. 14 Barnard College seniors. Modal age, 22.
8. 24 asylum attendants. Modal age, 25.
9. 12 workhouse inmates. Modal age, 30.
10. 24 clerks and business men. Modal age, 30.
11. 16 graduate students, instructors, and professors. Modal age, 32.
12. 24 prison inmates. Modal age, 34.

CHAPTER III

RESULTS

The Tables.—To set forth in full the individual records of the twelve groups of subjects mentioned on page 33 would require an excessive amount of space, and I have accordingly limited the detailed presentation to two groups, one of 24 normal-college seniors, and the other of 17 students in a course in experimental psychology in the normal college. These subjects are all young women. Their records are given in Tables I.–X., which are self-explanatory, except perhaps for the columns numbered 5 and 6, 8 and 9, and 11 and 12. These give the average results for the quarters and for the halves of

TABLE I

20 Digits. Normal-College Seniors. Girls

1	2	3	4	5	6	7	8	9	10	11	12
		Method Three				Method One			Method Two		
Subject	Time of First Learning, Min.	Time After One Week, Min.	Percent. of Time Saved or Amount Retained.			Score Per Cent.			Score Per Cent.		
El. W.	2.25	.66	69	61	63	33	28	27	40	35	34
Ed. W.	3.00	1.16	61			34			39		
H. B	4.50	1.75	61			34			36		
F. Wi.	4.56	1.25	73			9			30		
M. K.	4.66	.50	89			37			40		
G. L.	5.00	4.33	13			19			27		
J. M.	6.00	2.33	61	65		30	26		34	32	
F. K.	6.00	3.00	50			27			32		
A. H.	6.16	2.80	55			24			37		
R. W.	7.00	2.50	64			26			30		
C. C.	8.00	2.00	75			20			27		
H. M.	8.25	1.40	83			29			34		
A. N.	8.25	2.33	72	70	71	23	23	22	34	36	36
M. T.	8.25	1.16	86			30			41		
F. Sc.	8.33	3.66	56			19			31		
F. St.	8.66	2.50	71			27			34		
B. O.	12.00	2.66	78			23			43		
S. T.	13.00	5.88	55			18			31		
A. T.	15.00	9.80	35	72		9	20		23	36	
E. S.	16.80	3.50	79			19			46		
L. J.	20.16	2.40	88			26			40		
E. R.	20.16	2.00	90			33			47		
E. T.	21.50	5.00	77			8			22		
J. Mc.	29.00	11.50	60			26			35		
Aver.	10.26	2.76	67			24			35		

the groups, when the individuals are arranged, as they are in each table, in the order of their quickness of learning the material. Thus, in Table I., Column 5 informs us that the quickest quarter of the group in learning 20 digits saved 61 per cent. in relearning, the second quarter 65 per cent., the third quarter 70 per cent., and the lowest quarter 72 per cent.; and Column 6 tells us that the upper half of the group, in respect to speed of learning, saved 63 per cent. in relearning, while the lower half saved 71 per cent.

TABLE II

20 Nonsense Syllables. Normal-College Seniors. Girls

1	2	3	4	5	6	7	8	9	10	11	12
		Method Three				Method One			Method Two		
Subject	Time of First Learning, Min.	Time After One Week, Min.	Percent. of Time Saved or Amount Retained			Score Per Cent.			Score Per Cent.		
M. K.	12.00	4.00	67	68	71	17	26	26	49	47	44
El. W.	13.50	5.25	61			22			51		
Ed. W.	14.00	7.00	50			52			62		
F. St.	24.25	5.50	77			15			41		
A. T.	25.00	8.00	68			11			31		
H. B.	26.00	4.16	84			40			50		
A. H.	26.40	4.50	83	75		37	25		49	42	
F. Wi.	28.00	2.33	92			48			65		
R. W.	28.00	7.00	75			18			38		
E. S.	29.56	15.00	49			8			17		
F. Sc.	31.00	10.25	67			20			43		
B. O.	31.75	5.50	83			19			38		
A. N.	32.00	9.16	71	67	68	21	19	21	15	26	33
M. T.	33.50	13.40	60			7			18		
H. M.	34.00	8.80	74			18			40		
F. K.	34.00	6.40	81			21			30		
J. M.	35.50	15.66	56			17					
L. J.	36.08	15.00	58			29			29		
C. C.	37.00	16.50	55	69		12	23		36	40	
E. R.	40.80	15.16	63			39			53		
S. T.	42.00	13.00	69			14			18		
J. Mc.	42.00	12.66	70			18			41		
G. L.	44.16	4.50	90			46			52		
E. T.	45.00	15.40	66			6			38		
'Aver.	31.06	9.34	70			23			40		

Table XI. sums up the results of Tables I.–V. in condensed form, and Table XII. does the same for Tables VI.–X. The column numbers in these, as also in the following tables, correspond to those in the full Tables I.–X.

It should be understood that the "upper half" and the "lower half," for each material, consist of those individuals who fell into the respective halves of the group in the particular material studied.

The upper half does not, therefore, always include exactly the same individuals; and the average results, in Tables XI. and following, are obtained by combining the results of these various halves, and not by segregating the individuals who on the average learned the most or the least quickly.

TABLE III

20 Words. Normal-College Seniors. Girls

1	2	3	4	5	6	7	8	9	10	11	12
		Method Three				Method One			Method Two		
Subject	Time of First Learning, Min.	Time After Ten Weeks, Min.	Percent. of Time Saved or Amount Retained.			Score Per Cent.			Score Per Cent.		
A. H.	4.40	1.00	77	45	40	43	26	23	53	44	44
H. B.	5.00	4.66	7			12			43		
El. W.	7.00	3.88	43			35			50		
G. L.	7.66	4.66	39			11			39		
Ed. W.	9.00	3.08	66			31			51		
A. N.	9.50	6.00	37			22			28		
R. W.	10.25	5.00	51	35		20	20		52	45	
A. T.	10.40	6.75	35			14			41		
M. T.	11.00	7.50	32			20			40		
E. S.	11.00	8.75	21			17			39		
B. O.	11.25	6.75	40			27			49		
J. M.	11.50	8.00	30			22			48		
F. St.	11.66	6.88	41	54	61	26	22	20	46	37	35
S. T.	12.00	4.40	63			3			21		
F. Sc	12.16	4.00	67			22			40		
C. C.	13.00	3.75	71			32			49		
M. K.	13.25	3.66	72			19			30		
H. M.	13.33	12.25	8			28			34		
F. Wi.	13.80	4.16	70	68		17	18		37	33	
J. Mc.	14.00	7.25	48			16			31		
F. K.	14.33	4.00	72			16			27		
E. R.	15.00	3.50	77			40			50		
L. J.	16.00	2.08	87			7			38		
E. T.	28.50	13.00	54			9			17		
Aver.	11.88	5.62	51			21			39		

Tables XIII. and XIV. give the condensed result for each material from two other groups of subjects, whose records are not presented individually; while Tables XV. and XVI. present the results from all the groups in still greater condensation. The entries in Tables XV. and XVI. correspond to the average results from all materials combined, as presented at the bottom of Tables XI.–XIV.

Another way of combining the results from the use of the different materials is illustrated in Table XVII., which again is derived from Tables I.–V. The 24 individuals in the group were arranged in the order of their success in each test, and were given numbers indicating their rank or position in the group. The table gives the rank of each individual in each performance, and his average rank in speed of learning, in retention as measured by the saving method ("method three"), in recall ("method two"), and in recall after partial relearning ("method two"). The average deviation of rank of each individual in each of these kinds of performance is also given.

TABLE IV

PROSE. 100 WORDS (THE DIAMOND BRIGHT DAWN) NORMAL-COLLEGE SENIORS. GIRLS

1	2	3	4	5	6	7	8	9	10	11	12
		Method Three				Method One			Method Two		
Subject	Time of First Learning, Min.	Time After Ten Weeks, Min.	Percent. of Time Saved or Amount Retained.			Score Per Cent.			Score Per Cent.		
Ed. W.	10.00	1.33	87	78	68	27	66	59	98	82	80
F. Sc.	10.40	2.16	79			50			89		
A. H.	13.00	1.00	92			42			99		
E. S.	13.00	4.40	66			46			50		
El. W.	13.75	4.00	71			56			85		
C. C.	14.33	4.25	70			77			73		
R. W.	15.00	4.66	69	59		49	53		78	79	
F. Wi.	15.25	6.00	61			14			68		
F. K.	16.08	4.50	72			97			91		
G. L.	17.00	11.25	34			44			72		
H. B.	17.00	5.40	68			93			87		
J. M.	17.25	8.50	51			33			75		
F. St.	18.66	6.50	65	64	66	69	46	46	64	64	67
H. M.	19.50	10.00	49			62			52		
A. N.	22.25	9.00	60			52			76		
B. O.	23.25	9.50	59			45			80		
A. T.	24.25	5.56	78			39			37		
M. K.	25.16	7.40	71			45			73		
S. T.	26.08	4.00	85	68		84	47		95	70	
M. T.	28.00	15.00	46			51			60		
L. J.	29.80	17.00	43			32			54		
E. R.	31.40	6.56	79			20			89		
J. Mc.	34.56	6.88	80			69			55		
E. T.	45.16	11.75	74			76			67		
Aver	20.84	6.94	67			53			74		

Finally, Table XVIII. is derived from the preceding table for a purpose which will be explained later.

Time of Initial Learning.—An examination of any of the tables will reveal the fact that the time of initial learning varies widely with the different subjects, and that these differences in learning are more marked than the individual differences in relearning. In other words, it may be stated as a general rule that with a given number of individuals, there will be a greater difference in their time of memorizing than in their retentive capacity.

Generally speaking, with a group of 20 or 30 subjects, the time taken by the quickest learner is to the time taken by the slowest learner as 1:4. This, however, would seem to depend partly upon the nature of the material learned. Among the 24 Albany Normal College seniors (Tables I. to V.) it will be noticed that with *digits* the time of the quickest learner is to the time of the slowest learner as 1:13; that with *nonsense-syllables* the ratio is 1:4; that in the case of *words* the ratio is 1:7; that for *prose* it is 1:5; whereas for *poetry* it is 1:10. The difference in these ratios is, of course, largely a matter of chance. Take, for example, the table for *words:* here the slowest learner takes 28 minutes and 30 seconds, whereas the next slowest learner takes only 16 minutes. It is obvious that a much fairer form of comparison is that of comparing the average of the first four with the average of the last four. Doing this we find that the ratios are as

TABLE V

POETRY. 100 WORDS (GENTLE ELLEN) NORMAL-COLLEGE SENIORS. GIRLS

1	2	3	4	5	6	7	8	9	10	11	12
		Method Three				Method One			Method Two		
Subject	Time of First Learning, Min.	Time After Ten Weeks, Min.	Percent. of Time Saved or Amount Retained.			Score Per Cent.			Score Per Cent.		
El. W.	2.08	1.00	52	65	61	36	56	59	59	72	73
H. B.	3.00	1.75	42			95			98		
Ed. W.	3.25	.33	90			64			100		
R. W.	5.00	1.40	72			30			39		
E. S.	7.00	4.50	36			11			36		
A. H.	7.50	0.00	100			97			100		
B. O.	8.66	3.88	56	57		96	63		99	74	
G. L.	8.80	6.16	30			28			50		
A. N.	9.50	4.40	54			57			55		
F. Sc.	10.00	2.16	78			59			87		
H. M.	10.00	5.25	48			77			82		
F. Wi.	10.16	2.25	78			60			71		
S. T.	10.50	2.00	81	62	65	10	43	40	35	65	57
E. R.	10.56	3.80	64			78			92		
M. T.	10.75	5.00	53			51			84		
F. K.	12.25	7.16	58			73			89		
M. K.	13.40	5.08	62			23			44		
E. T.	13.75	6.33	54			24			48		
C. C.	14.00	3.08	78	68		46	37		67	49	
J. M.	15.75	6.25	60			36			47		
J. Mc.	17.00	5.75	66			39			42		
F. St.	17.16	5.08	71			13			31		
A. T.	19.75	5.50	72			32			40		
L. J.	20.00	7.66	62			53			68		
Aver.	10.83	4.00	63			50			65		

follows: for digits 1:6; nonsense-syllables 1:3; words 1:3; prose 1:3; poetry 1:5.[1]

An individual who is a quick learner of one sort of material tends, upon the whole, to be a quick learner of other sorts also. This is seen most conveniently in the first part of Table XVII., which shows the ranks of 24 individuals in quickness of learning five sorts of material. Some individuals stand consistently high, and some consistently low. There is, however, a good deal of shifting from one material to another, and this shifting finds expression in the coefficient of correlation between the ranking in two materials. As computed by the rank-difference method, the average correlation between the speed of learning any two sorts of material is, for this group of subjects, $+.51$. For the 17 subjects whose records are given in Tables VI.–X., the average correlation comes out a little lower, $+.42$. The shifting of an individual's rank from one material to another is partly due to the accidental factors inherent in a single

TABLE VI

20 DIGITS. CLASS IN EXPERIMENTAL PSYCHOLOGY. GIRLS

1	2	3	4	5	6	7	8	9	10	11	12
		Method Three				Method One			Method Two		
Subject	Time of First Learning, Min.	Time After One Week, Min.	Percent. of Time Saved or Amount Retained.			Score Per Cent.			Score Per Cent.		
B. B. ...	3.40	0.75	78	57	58	39	30	25	39	33	30
F. Wo. ..	4.50	4.16	8			19			22		
E. F. ...	6.00	0.88	85			34			37		
J. S.	6.50	2.75	58			27			32		
E. C. ...	6.50	1.33	80	58		29	21		35	27	
I. S.	8.00	1.66	79			35			39		
A. D. ...	8.56	9.66	13			8			14		
B. C.	9.00	1.33	85			10			21		
El. F. ...	9.80	0.50	95	80	81	38	25	24	40	34	32
A. Q. ...	10.00	3.25	68			24			32		
E. H. ...	11.00	2.40	78			20			33		
E. H. ...	11.30	2.25	80			18			30		
M. J. ...	11.80	1.33	89	82		25	24		34	30	
G. H. ...	12.66	4.80	62			6			16		
H. A. ...	14.00	0.16	99			40			40		
R. B. ...	16.16	1.66	90			27			33		
M. N. ...	24.25	6.75	72			22			25		
Aver. ...	10.20	2.68	70			25			31		

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[1] Even when we thus obtain our ratio by comparing the average of the first four subjects with the average of the last four, the P.E. is very large. It is a noticeable fact, however, and one of some interest, that with every group of subjects the greatest difference (ratio) occurs with the *digits*.

test, and partly, no doubt, to actual differences in the efficiency of the individual's powers of memorizing different classes of material.

Interval between Learning and Reproduction.—This interval varied in different experiments, as indicated in the several tables. In the majority of my experiments the interval that was allowed to elapse for digits and nonsense-syllables was either three days or one week, whereas for words, prose and poetry it was much longer, being from three to ten weeks. In an investigation of this nature, where we are concerned primarily with acquisition as related to retention, we can of course choose any interval we wish. We might wait six months and still find a relation between learning and retention. That this relation would differ with the interval, however, appears probable from certain tests I have made where the longer interval gave a negative correlation. I have not studied the matter systematically, and the data presented in this paper do not show any clear difference according to the interval employed. In general, we may suppose, the difference in amount reproduced by quick and slow learners tends to become less, since the amounts retained by all approach zero with time.

TABLE VII

12 NONSENSE SYLLABLES. CLASS IN EXPERIMENTAL PSYCHOLOGY. GIRLS

1	2	3	4	5	6	7	8	9	10	11	12
		Method Three				Method One			Method Two		
Subject	Time of First Learning, Min.	Time After One Week, Min.	Percent. of Time Saved or Amount Retained.			Score Per Cent.			Score Per Cent.		
J. S.	6.08	0.75	88	84	79	29	37	37	63	59	55
E. H.	6.75	1.33	80			16			40		
B. B.	7.50	1.16	85			53			72		
E. F.	9.16	1.66	82			49			60		
E. C.	10.00	2.80	72	74		39	37		48	50	
G. H.	11.00	5.56	49			34			40		
El. F.	11.50	1.00	91			47			68		
B. C.	12.00	2.16	82			29			45		
A. D.	13.66	5.33	61	73	65	20	28	23	31	40	31
A. Q.	14.00	3.08	78			32			40		
M. J.	14.25	5.16	64			18			36		
I. S.	16.00	1.66	90			42			54		
F. Wo.	17.00	9.16	46	41		12	18		19	23	
H. A.	18.50	4.88	74			17			39		
E. A.	19.33	5.50	72			21			19		
R. B.	31.00	12.08	61			24			22		
M. N.	32.56	19.25	40			10			18		
Aver.	14.72	4.74	71			30			42		

AMOUNT RETAINED

Method 1.—Method 1 has already been described in Section 2 of the preceding chapter. It shows the amount that can be reproduced, after the lapse of a certain time interval, of the material originally memorized,—this reproduction being without a fresh presentation. By consulting columns 7, 8, and 9 of any table, it will be noticed that in the case of all materials, both *meaningless* and *logical,* there appears to be a positive correlation between quickness of learning and the amount retained. The score obtained by the first half[2] is in general better than that obtained by the last half. This is most marked in the case of *prose* and least marked with *digits.* In fact with *digits,* the score obtained by the last half is, in several cases, very nearly as high as the first half, and in the case of the high-school students (Table XIV.), the score of the last half is even better. In any case, however, the difference is small. With *nonsense-syllables, words,* and *poetry* the difference is slightly in favor of the quick learners, although on the whole the difference is but slight. The probable error,

TABLE VIII

20 WORDS. CLASS IN EXPERIMENTAL PSYCHOLOGY. GIRLS

1	2	3	4	5	6	7	8	9	10	11	12
		Method Three				Method One			Method Two		
Subject	Time of First Learning, Min.	Time After Ten Weeks, Min.	Percent. of Time Saved or Amount Retained.			Score Per Cent.			Score Per Cent.		
B. B. ...	5.80	2.08	64	56	50	28	28	21	53	47	42
E. F. ...	7.33	2.66	64			31			39		
E. A. ...	7.40	2.25	70			34			50		
F. W. ...	8.00	6.00	25			17			44		
E. C.	8.56	4.50	47	45		21	15		42	37	
B. C.	9.16	4.66	49			20			45		
A. D.	9.16	6.40	30			9			29		
A. Q.	10.08	4.80	52			11			30		
J. S.	10.08	1.88	81	57	61	43	23	21	60	37	35
I. S.	12.00	6.00	50			21			39		
M. J. ...	13.16	6.33	52			16			28		
H. A. ...	13.50	7.33	46			13			22		
G. H. ...	14.50	7.75	47	63		6	19		21	33	
El. F. ...	15.08	6.40	58			19			35		
E. H. ...	15.33	4.24	72			12			28		
M. N. ...	17.00	5.00	71			19			34		
R. B. ...	19.00	6.08	68			39			49		
Aver. ...	11.48	4.96	56			21			38		

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[2] In the following pages we shall by "First half" or "Upper half" hereafter understand the quickest learners, and by "Last half" or "Lower half" the slowest or poorest learners.

this, indeed, agrees with the result by the other methods. With *poetry* the same relation often holds good, but the results are not uniform, and, as may be seen from Tables XI. and XII., the quick learners may, by this computation, forget even more, but in any case the difference is not marked. Taking *prose* and *poetry* together, however, and assuming that they are illustrative of "logical" or "meaningful" material, we may say that the results obtained agree with those obtained by Methods 1 and 2. Taking all three methods into consideration, we are entitled to say that with material that is *logical* in character, *those who learn quickly remember the longest.*

TABLE XI

24 Normal College Seniors

1	2	3	6	9	12
Digits:					
Upper half	5.5	2.0	63	27	34
Lower half	15.0	4.0	71	22	36
Nonsense-syllables:					
Upper half	24.1	6.5	71	26	44
Lower half	38.0	12.1	68	21	36
Words:					
Upper half	10.0	5.5	40	23	44
Lower half	14.8	5.7	61	20	35
Prose:					
Upper half	14.3	4.8	68	59	80
Lower half	27.3	9.1	66	46	67
Poetry:					
Upper half	7.0	2.8	61	59	73
Lower half	14.5	5.2	65	40	57
Average:					
Upper half	12.2	4.3	61	39	55
Lower half	21.9	7.2	66	30	46

The "time interval" here, as in Tables XII. and XIV., is 1 week for the digits and nonsense-syllables and 10 weeks for the prose and poetry. In Table XIII. the "time interval" is 3 weeks for *all materials.*

With digits, however, a material the memorizing of which is so-called "rote" memory, we find that the conditions are, so far as Method 3 is concerned, reversed, for here it is the quick learners who seem to forget the most. With *digits* the amount forgotten, as ascertained by Method 3, is always greater for the upper half of the class, and not only is this always so, but the difference between the two halves of the class is generally marked. This result is not strongly contradicted by Methods 1 and 2, according to which the difference is slight. At any rate we may say with some degree of certainty that, in the main, those who memorize digits slowly are more apt to retain them than those who memorize them quickly. This is just the opposite of the statement made for prose and poetry, and digits being an "opposite" form of material, so to speak, one might make the inference that those who learn *slowly* remember *long,* if the material used is such as involves *motor associations,* but that they forget *quickly* if the material is logical in character, *e. g.,* prose, and to a somewhat less extent, poetry.

TABLE XII

17 NORMAL COLLEGE SENIORS

1	2	3	6	9	12
Digits:					
Upper half	6.5	2.8	58	25	30
Lower half	13.5	2.5	81	24	32
Nonsense-syllables:					
Upper half	9.2	2.0	79	37	55
Lower half	19.5	7.3	65	23	31
Words:					
Upper half	8.2	4.2	50	21	42
Lower half	14.4	5.7	61	21	35
Prose:					
Upper half	14.6	5.4	62	51	79
Lower half	27.3	10.0	63	21	49
Poetry:					
Upper half	9.0	4.0	55	53	79
Lower half	13.2	3.7	72	50	76
Average:					
Upper half	9.5	3.7	61	37	57
Lower half	17.6	5.8	68	28	45

The difference between Tables XI. and XII. is probably due largely to the fact that the "materials" used are not identical.

In this group of subjects only 12 nonsense-syllables were used.

Such a statement, however, is true only in a very rough way. In the first place, *nonsense-syllables,* a material that is not only "unmeaningful" in character, but that involves the "memorizing," so to speak, of motor associations, seems—so far as Method 3 is concerned—to side more with the *prose* than with digits. On the other hand, *words,* a material that, one would think necessitated the formation of logical associations, partakes (so far as Method 3 is concerned) of the nature of *digits,* for the "upper half" always retains less than the "lower half." Just why this should be is difficult to say, and I have no satisfactory explanation to offer.

With *prose* and *poetry* our results by all these methods are quite uniform. As this material is essentially "logical" in character our results do not disagree with those obtained by Henderson,[4] Thorndike,[5] and Pyle,[6] each of whom found that those who learn quickly retain more than those who learn slowly, for the material they used was not such as involved the learning of motor associations, as is largely the case with *digits* and, with many individuals, even with *words.*

Taking all three methods into consideration, however, and averaging the results we find that, with *all* materials, excepting *digits,* those who learn quickest forget the least. The contrary result obtatined with digits should not be considered in any way remarkable or contradictory,—the associations formed in memorizing digits being quite different from those formed in the momorizing of words and nonsense-syllables. Not that logical associations are invariably formed in the memorizing of nonsense-syllables, but when associations are formed they are of the same type as those formed in the memorizing of words. In short, the nonsense-syllable is first converted into a word, and the word is then "memorized."

TABLE XIII

20 Columbia College Men Students

1	2	3	6	9
Digits:				
Upper half	3.5	1.6	49	18
Lower half	7.4	2.6	62	18
Nonsense-syllables:				
Upper half	8.0	3.7	52	22
Lower half	16.0	7.2	51	20
Words:				
Upper half	6.9	2.3	66	38
Lower half	14.5	3.0	79	35
Prose:				
Upper half	8.5	1.6	80	65
Lower half	13.8	4.0	72	51
Poetry:				
Upper half	7.9	1.6	81	73
Lower half	11.8	3.3	73	63
Average:				
Upper half	7.0	2.2	66	43
Lower half	12.7	4.0	67	37

"Method 2" was not tried with these subjects.

In this group of subjects only 12 nonsense-syllables were used.

The passage of prose was relatively easier than that used in Tables XI. and XII. hence the shorter time.

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[4] "A Study of Memory," *Psy. Rev. Monog. Supp.*, No. 23, 1903.

[5] "Memory for Paired Associates," *Psy. Rev.*, 1908, **15**, 122.

[6] "Retention as Related to Repetition," *Jour. of Ed. Psy.*, 1911, **2**, 311.

We have already considered the question concerning the degree to which the extremes at each end of a series should be considered, and, whether or not they should be taken at their face value. The method of averaging the two halves of each group, so that the average of the first half may be compared with the last half, tends, as we have already said, to "tone down" or lower the significance of these extremes by immersing them with the remainder of the "half-class" to which they belong. Arguments may be made both for and against this procedure. In the first place it may justly be contended that it is these very extremes that are most valuable—and that the comparison of most worth would be that in which the first two or three individuals were compared with the last two or three. On the other hand it is possible that it is precisely these extremes that are most to be suspected of error, and that the chance of error is lessened by taking the average or the median of each half of the class.

TABLE XIV

60 High School Boys and Girls

1	2	3	6	9	12
Digits:					
Upper half	6.0	2.6	62	21	28
Lower half	14.1	3.1	74	22	31
Nonsense-syllables:					
Upper half	25.3	8.0	68	30	48
Lower half	38.7	10.9	68	23	35
Words:					
Upper half	9.5	4.8	48	25	44
Lower half	15.0	6.0	60	23	36
Prose:					
Upper half	15.4	5.2	68	57	74
Lower half	26.1	10.1	61	38	60
Poetry:					
Upper half	6.0	3.3	65	61	84
Lower half	13.6	3.7	61	51	80
Average:					
Upper half	12.4	4.8	62	39	55
Lower half	21.5	7.0	65	31	48

Roughly speaking, the Pearson method may be said to do away with both of these objections, for, while it takes into consideration the actual amounts themselves, it tends to lower the significance of the extremes more than does the method of comparing the average of one half of the class with the other.

The Pearson method was used with every group of subjects for determining certain of the correlations considered below. It is evident that the data given in the tables supply material for the working out of several correlations. Of these the four most important are: (1) Column 2 with 3; (2) Column 2 with 4; (3) Column 2 with 7; and (4) Column 2 with 10.

These four correlations have been worked out for every group of subjects.

Of the four correlations mentioned, the first, Column 2 with Column 3, is, with a few exceptions, positive. The exceptions are not confined to any one material though they occur mostly with the *digit* tables. The correlation is fairly high, averaging between .5 and .6.

The second correlation—Column 2 with Column 4—belongs to Method 3. Here, of course, the correlations tend to correspond to the relation shown by the two figures of Column 6 but this is not inva-

TABLE XV

SEVERAL GROUPS

1	2	3	6	9	12
		Method Three		Method One	Method Two
	Time of First Learning, Min.	Time of Relearning	Per Cent. of Time Saved	Score Per Cent.	Score Per Cent.
40 Grammar School Girls. Modal Age, 14					
Av. upper half	13.2	5.0	60	37	55
Av. lower half	20.1	6.9	64	28	54
24 Trade School Boys. Modal Age, 16					
Av. upper half	11.4	4.2	59	35	52
Av. lower half	19.2	7.3	60	26	41
60 High School Students. Both Sexes. Modal Age, 17					
Av. upper half	12.4	4.8	62	39	55
Av. lower half	21.5	7.0	65	31	48
132 Normal College Women Students. Modal Age, 21					
Av. upper half	11.2	4.0	61	39	56
Av. lower half	17.8	6.4	65	31	47
24 Asylum Attendants. Both Sexes. Modal Age, 25					
Av. upper half	14.1	5.2	58	35	52
Av. lower half	18.3	7.2	62	28	41
12 Clerks and Business Men. Modal Age, 30					
Av. upper half	12.2	4.4	61	37	49
Av. lower half	20.0	7.1	67	30	39
16 Graduate Students and Professors. Men. Modal Age, 32					
Av. upper half	11.1	3.8	61	41	
Av. lower half	16.9	6.1	63	33	

The interval between first learning and relearning was, in the groups included in this table, one week for digits and nonsense-syllables, and ten weeks for words, prose and poetry.

riable. For example, with Tables I. to V. the correlations are all negative with the exception of *prose*—and here the correlation is so low and the P.E. so large that the index obtained is practically of no value. In fact nearly all of these "Method 3" correlations are extremely low and their only value is to show that, so far as Method 3 is concerned, there is practically no correlation between the rapid learning and retention.

The third correlation—Column 2 with Column 7—belongs to Method 1. The correlation is, with the exception of *digits*, always positive, *i. e.*, such as to show a correspondence between quickness of learning and retention, when the latter is measured by the amount recalled after the interval. It is not, however, a very high correlation, seldom going above .4 and averaging only .25.

TABLE XVI

Several Groups

1	2 Time of First Learning, Min.	3 Time of Relearning, Min.	6 Per Cent. of Time Saved	9 Score Per Cent.	12 Score Per Cent.
24 State Reformatory Inmates. Males. Modal Age, 20					
Av. upper half	6.2	2.1	68	50	71
Av. upper half	12.2	3.9	70	43	62
32 Columbia College Seniors. Men. Modal Age, 22					
Av. upper half	9.1	2.7	68	42	
Av. lower half	12.9	5.0	70	35	
14 Barnard College Seniors. Women. Modal Age, 22					
Av. upper half	7.0	2.2	66	40	
Av. lower half	11.8	4.5	69	33	
12 Workhouse Inmates. Men. Modal Age, 26					
Av. upper half	10.3	4.5	68	40	66
Av. lower half	16.0	5.4	69	32	54
24 Prison Inmates. Men. Modal Age, 34					
Av. upper half	9.9	4.1	70	39	
Av. lower half	14.3	5.0	72	37	

The interval between the first learning and the relearning was, for the groups included in this table, three weeks for all materials.

The fourth correlation—Column 2 with Column 10—belongs to Method 2. Generally speaking the index obtained agrees fairly closely with that of Method 1. In view of the fact that the material is read once to the subject Method 2 allows a certain amount of relearning and thus approaches Method 3. This is seen in several of the correlations obtained.

Even though, as just stated, the general statistical relation between speed of learning and retentiveness is very loose, it might still be true that there was a class of quick learners who were poor in retention,

TABLE XVII

Rank According to

	Time of First Learning							Amount Retained (Method Three)							Score (Method One)							Score (Method Two)						
	Prose	Digits	Nonsense Syllables	Words	Poetry	Average	Average Deviation	Prose	Digits	Nonsense Syllables	Words	Poetry	Average	Average Deviation	Prose	Digits	Nonsense Syllables	Words	Poetry	Average	Average Deviation	Prose	Digits	Nonsense Syllables	Words	Poetry	Average	Average Deviation
Ed. W...	1	2	3	5	3	2.8	1.0	2	15	23	8	2	10.0	5.2	1	2	1	5	7	3.2	2.2	2	8	2	3	1	3.2	1.9
F. Sc....	2	15	11	15	10	10.6	3.6	4	20	15	9	5	10.6	5.3	11	19	11	11	9	13.4	3.9	5	18	10	13	7	10.6	3.9
A. H....	3	9	7	1	6	5.2	2.6	1	19	4	2	1	5.4	5.4	2	14	6	1	1	8.4	4.1	1	9	8	1	2	4.2	3.4
E. S.....	4	20	10	10	5	9.8	4.2	15	7	24	22	23	18.2	5.7	20	20	22	16	23	20.2	1.5	23	2	23	15	22	17.0	6.8
El. W....	5	1	2	3	1	2.4	1.3	10	13	18	14	18	14.6	2.7	6	4	8	3	15	7.2	3.4	8	5	5	4	13	7.0	2.8
C. C. ...	6	11	19	16	19	14.2	4.6	12	9	22	7	6	11.2	5.1	8	17	19	4	13	12.4	4.9	13	22	18	7	12	14.4	4.4
R. W....	7	10	9	7	4	7.4	1.7	13	14	8	12	8	11.0	2.4	10	11	13	12	18	12.8	2.1	10	19	15	2	21	13.4	5.9
F. W....	8	4	8	19	12	10.2	4.2	17	10	1	6	4	7.6	4.7	15	22	2	15	8	12.4	5.9	16	20	1	17	10	12.8	5.8
F. K....	9	8	16	21	16	14.0	4.4	9	22	6	4	20	12.2	6.9	19	9	10	17	6	12.2	4.6	4	16	20	22	6	13.6	6.9
G. L.....10	6	23	4	8	10.2	5.1	24	24	2	17	24	18.2	6.9	16	18	3	21	19	15.4	4.9	15	21	4	14	15	13.8	3.9
H. B.....11	3	6	2	2	4.8	3.0	14	16	3	24	22	15.8	5.8	5	3	4	20	3	6.6	5.3	7	10	6	10	4	7.4	2.1
J. M....12	7	17	12	20	13.6	3.9	20	17	21	21	14	18.6	2.9	11	6	17	10	16	12.0	3.6	12	13	17	8	17	13.4	2.8
F. St....13	16	4	13	22	13.6	4.3	16	12	7	15	9	11.8	2.7	21	10	18	8	22	15.8	4.8	18	15	12	9	24	15.6	4.3
H. M....14	12	15	18	11	1.4	2.0	21	5	9	23	21	15.8	7.0	23	8	14	6	5	11.2	5.4	22	12	13	18	9	14.8	4.1
A. N.....15	13	13	6	9	11.2	3.0	18	11	10	18	17	14.8	3.4	7	16	9	9	10	10.2	1.9	11	14	9	21	14	13.8	3.0
B. O.....16	17	12	11	7	12.6	3.1	19	6	5	16	15	12.2	5.7	5	15	12	7	2	8.2	4.2	9	3	16	6	3	7.4	4.1
A. T.....17	19	5	8	23	14.4	6.3	7	23	13	19	7	13.8	5.4	22	23	21	19	17	20.4	1.9	24	23	19	11	20	19.4	3.5
M. K....18	5	1	17	17	11.6	6.9	11	2	14	5	12	8.8	4.1	12	1	16	14	21	12.8	5.0	14	6	7	20	18	13.0	5.2
S. T.....19	18	21	14	13	17.0	2.8	3	21	12	10	3	9.8	7.2	18	21	20	24	24	21.4	2.0	3	17	22	23	23	17.6	6.1
M. T....20	14	14	9	15	14.4	2.5	22	4	19	20	16	16.2	4.9	14	7	23	13	12	13.8	3.7	19	4	24	12	8	15.5	7.1
L. J.....21	21	18	23	24	21.4	1.7	23	3	20	1	13	12.0	8.0	9	12	7	23	11	12.4	4.2	21	7	21	16	11	15.2	4.9
E. R.....22	22	20	22	14	20.0	2.4	6	1	17	3	11	7.6	5.1	4	5	5	2	4	4.0	1.0	6	1	3	5	5	4.0	1.6
J. Mc....23	24	22	20	21	22.4	1.3	5	18	11	13	10	11.5	3.3	13	13	15	18	14	14.6	1.5	20	11	11	19	19	16.0	4.0
E. T....24	23	24	24	18	22.6	1.8	8	8	16	11	19	12.4	4.0	24	24	24	22	20	22.8	1.4	17	24	14	24	16	19.0	4.0
Average..						1.25	3.2						12.5	5.0						12.5	3.5						12.5	4.3
A. D....						4.3							2.7							3.8							3.7	

and a class of slow learners who were good in retention. Such is the common belief, no doubt, and such a view is sometimes expressed in psychological literature. In attempting to judge of the correctness of this view, we must not be misled by chance coincidences. In a series of single tests, it is almost certain to happen that an individual who learns a certain selection quickly shall be found to retain it poorly, or that one who learns it slowly shall be found to retain it well. In the absence of a general statistical confirmation of this relation, a few such isolated cases have little significance. But if it is found, by repeated tests of the same individual, that he regularly learns quickly and regularly forgets quickly, then his case is significant as showing that individuals do exist who are distinctively quick learners and poor retainers. My tests afford some opportunity for examining this question, since each individual was tested with five different materials. Table XVII., giving the ranks of 24 individuals in learning each material, and in recalling and relearning it after an interval, affords an opportunity for looking for individuals who are consistently quick or slow learners and for finding how well they do in retention. Table XVIII. extracts from Table XVII. the records of the most consistent individuals.

TABLE XVIII

Average Ranks and Variabilities of the Most Consistent Individuals

	Learning		Recall (Method 1)		Relearning (Method 3)	
Individual	Av. Rank	A.D. of Rank	Av. Rank	A.D.	Av. Rank	A.D.
Ed. W.	2.8	1.0	3.2	2.2	10.0	5.2
A. H.	5.2	2.6	4.8	4.1	5.4	5.4
R. W.	7.4	1.7	12.8	2.1	11.0	2.4
A. N.	11.2	3.0	10.2	1.9	14.8	3.4
S. T.	17.0	2.8	21.4	2.0	9.8	7.2
E. R.	20.0	2.4	4.0	1.6	7.6	5.1
J. Mc.	22.4	1.3	14.6	1.5	11.5	3.3
E. T.	22.6	1.8	22.8	1.4	12.4	4.0
General Av.	12.5	3.2	12.5	3.5	12.5	5.0

Regarding these individuals, it may be noted that:

Ed. W., while consistently high in learning and recall, occupies a medium and rather variable position in relearning.

A. H. stand high on the average throughout, but is rather variable in recall and relearning.

R. W. and A. N. are consistently medium throughout.

S. T. is consistently low in learning and recall, but variable in relearning.

E. R., the most interesting case, is consistently low in learning, consistently high in recall, and high, though only moderately consistent, in relearning.

J. Mc. is consistently low in learning, and consistently medium in recall and relearning.

E. T. is consistently low in learning and in recall, and consistently medium in relearning.

There is no one, then, who is consistently high throughout, or who is consistently low throughout, though there are two who are consistently medium throughout.

On the other hand, no one who is consistently high in learning is consistently low in retention. But there is one individual, E. R., who is consistently low in learning and consistently high in retention; and another, J. Mc., who is consistently low in learning and consistently medium in retention. It is reasonable to suppose that these two persons, especially the former, overlearned the material on the first learning. Through excess of caution, they delayed presenting themselves for the test of learning until they were extra sure of their material. So we may suppose. If so, this moral trait of caution would produce the spurious appearance of a connection between slow learning and good retention.

Examination of Tables VI.–X. shows that among the 17 individuals included there is one who was consistently low in learning and rather consistently medium in retention, and one who is consistently medium in learning and rather consistently high in retention; but none who is consistently high in learning and consistently medium or low in retention.

Of the 41 individuals whose records are here presented in full, then, there is no case of an individual who can be definitely classed as a quick learner and as a poor retainer. There are several quick learners whose average position in retention is considerably lower than their position in learning, but the variability of their position, as regards retention, makes it impossible to place them definitely.

Intellectual Standing (*Mental Ability.*)—A comparison of the results given by the various groups of subjects (*e. g.*, hospital attendants with college students) leads us to suspect that there is a direct relation between capacity or ability to learn, and general intelligence. Most of those who have investigated this matter have arrived at the same conclusion. Jacobs,[7] for example, states that there is a "notable concomitance" between school standing and "span of prehension." Others, however, Bolton and Ebbinghaus, for example, deny that any such correlation exists. Their results, however, were derived in large part from examinations of single groups that were fairly homogeneous and not by a comparison of one type of intellectuality with another.

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[7] *Mind*, Vol. 12, 1887. Others who have obtained a positive correlation, though not so high as Jacobs, are Binet, Bourdon, Burt, Pohlmann, Smedley, Winch and Wessley.

We can not here go into a detailed examination of all the results shown in the tables for the reason that space does not permit giving the complete data. But we may say that, to a certain extent, the correlation depends upon the material used. It was found that where the material is logical in character, especially in the case of prose, the college graduates do better than clerks and office men of the same average age, and that these do better than asylum attendants; that college students do better than inmates of reformatories, and that Barnard College seniors do better than the female servants of the same age. The differences, however, are not marked. Upon taking any one form of material, contrary results may obtain. Thus, *e. g.*, the businessmen and clerks do slightly better with prose than do college students of the same age, while with poetry they do worse. With nonsense-syllables the order is very much the same as for prose, although here the senior college students do best of all. With digits the group of clerks and business men do better than any others excepting the classes in experimental psychology. We can not help but infer that this is due in a large measure to practise.

Such statements as the above, however, are more or less loose for the reason that they refer only to *groups* of subjects. *Some* of the hospital attendants may have been more intelligent than *some* of the college students. More exact results were obtained in classes where the general rank in class of each scholar could be ascertained—all his studies being taken into consideration. An examination of the class records of the 132 normal-college students proved "that the students who rank highest in their classes and who can be classed as *the most intelligent* have, as a rule, the best memories."[8] With the group in question the correlation between memory and standing in class was found to be .31.

Social Standing (*Occupation, Environment and Moral Conduct*).—By social standing we mean not only one's standing in society, from a "worldly point of view," but also from the point of view of the sociologist. Other things being equal, we wish to determine if any one occupation is more conducive to tenacity of impression than another. It will be noted that this problem is closely linked with the preceding; and as we used as subjects prisoners and reformatory inmates, we may say that it also bears on morality.

The group differences here like those for mental ability differ with the materials used. The differences where the *total material* is considered are best seen by consulting and comparing the appropriate tables. With *digits,* no correlations of any account were obtainable, though here, as before said, the business men and clerks seem to do better than any of the others with the exception of the group in experimental psychology. The business men are rather slow in learning the *nonsense-syllables* and their degree of retention of these is worse than any other group with the exception of the grammar-school students. With *words* they stand on a par with the high-school students but for *prose* they seem to do slightly better, both for time of initial learning and for relative amount forgotten. This is what we should expect, since we have found that there is a positive correlation between mental ability and memory capacity. With the poetry, however, they do not do so well as the high-school students and even drop slightly below the grammar-school students.

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[8] D. O. Lyon, *Jour. of Phil., Psych. and Sci. Methods*, 1912, 9, 74.

The inmates of the reformatories, and to a slightly less extent the prison, rank fairly high for *digits,* and *words,* so far as quickness of learning is concerned. For *nonsense-syllables* they do not rank so high. For *prose* and *poetry* they stand very well, ranking even higher than the college students. I feel that the explanation of this seeming discrepancy lies in the fact that the minds of reformatory inmates are very receptive while in confinement. Their life being for the most part a dull monotony, they welcome any novelty and enter upon the experiment with considerable zest. This is undoubtedly even more true as explaining their high degree of retentiveness for we are led to believe from a study of the ''introspections'' handed in that they review the material to themselves as a diversion. The average time for the criminal group is probably increased considerably by the fact that such groups invariably contain a small percentage of inmates of feeble mental mentality, either bordering on idiocy or afflicted with one of the numerous psychoses.

Age.—Speaking of memory in its broadest sense we may say that memory capacity increases with age. This statement is general in the extreme in that the rate of increase varies with the material used. Generally speaking, it was found that the increase in efficiency with age is greater in the case of prose than it is in poetry, and in both of these, greater than for either digits or nonsense-syllables.

Several investigators have performed experiments from which they conclude that there is a state of maximal efficiency that comes in the ''teens.'' At this period they maintain that the memory is stronger than at any other period, whether preceding or following it. To me it seems that the materials they have used have been too meager to deduce any such general conclusion. For example, Bernstein and Bogdanoff find this special ''memory period'' to occur about the age of 15. The only material they used on which they based this conclusion consisted of geometrical figures. To me it seems that the only conclusions one can derive from such an experiment is to say that when geometrical figures are presented to various subjects in a certain way and then tested for recognition after the lapse of a certain interval, the subjects around the age of 15 do on the average better than older students and adults.

With Method 1 I find that high-school students averaging from 16 to 17 in age retain more of the poetry than do the younger grammar-school students and the older college students. With prose the height of efficiency, as before said, appears much later in life and the more abstract and difficult the material the later it appears. This would probably have its limit, however, and even with Kant's ''Critique'' men of 50 would undoubtedly do better than men of 80. The difficulty experienced by the younger children in memorizing a nonsense-syllable is undoubtedly ascribed to many causes. Probably the chief of these is that nonsense-syllables are uninteresting, and though children may have a better retentive capacity than adults, their attentive capacity is decidedly inferior.

Sex.—Our object here is to discover if there is any difference in retentive capacity between the male sex and the female sex as a whole, and in particular if there is any difference between the relation of the time of learning to the amount retained in one sex from the other.

An examination and comparison of my tables (including some not here reproduced) shows that as a whole the women and girls do better in their initial learning than do the men and boys. Thus, *e. g.*, the Barnard College girls memorized the total material in a shorter time than did Columbia College men of the same age. For *digits, words, nonsense-syllables,* and *poetry,* the girls average better than the boys. With *prose* the women do better with the passage starting ''The diamond bright dawn,'' but the men do better with the passage starting ''The present study of monistic philosophy.'' These statements apply only to time of first learning. When we come to *retentiveness,* as ascertained by averaging Methods 1, 2, and 3, we find that though the girls still hold their superiority over the men in *digits, nonsense-syllables* and *poetry,* that the men stand equal with them in the case of *words,* while for prose the men even seem to do better.

CHAPTER IV

SUMMARY AND RECAPITULATION OF THE MAIN RESULTS

In the preceding chapters we have endeavored to set forth, more or less in detail, the various results obtained from the experiments performed. In a few cases conclusions were drawn, but in the main they were reserved for the present chapter.

Any attempt to classify these conclusions in a strict and exact manner meets with failure. An analysis of them, however, shows that they may be roughly put under two groups: (1) Those relating to methods and modes of experimentation and correlation and that partake more of the nature of *inferences.* (2) Those results that are drawn from the experiments described in this paper, be their limitations and imperfections what they may. The following is a brief recapitulation of the results, conclusions, and inferences of these two groups. Several of the following have been drawn from an examination of the "introspections."

Group 1.—(1) Memory is not a distinct, separate, and concrete faculty of the mind, but is complex in the extreme. Experiments such as those described in this paper, being limited in character, apply but to a small part of mentality—and hence, memory.

(2) *Association* and *retention* are closely related. It is a question as to how much we should consider the former in investigating the latter.

(3) The *relation* of quickness of learning to retentiveness depends upon the method used of ascertaining this "retentiveness." The different methods (*v.* p. 43) give opposite results, and yet, in one sense of the word, one method is as "correct" as another.

(4) Two people may have equal degrees of retentiveness but very unequal degrees of recollection. To test merely the power to recall is but to test a certain factor of memory.

(5) With the same subjects and the same method of experimentation, different materials give different results.

(6) In testing "memory" when taken in the fullest sense of the word we should test not only the so-called "rote" memory, but we should also consider the subject's ability to perceive relationships and associations, and his ability to memorize them.

(7) In relearning it is impossible to distinguish a facility of form-

ing new associations from a retention of subliminal associations. This disadvantage is carried by Method 3.

(8) "Method 1" has several drawbacks. The chief of these is that reproduction without a fresh presentation of the material originally learned, reveals only the strongest of the original impressions—the so-called "supraliminal associations."

(9) An examination of over 400 "introspections" would seem to show that it does not pay to attempt to multiply the various forms of imagery. The quickest learners employ the type, or combination of types, to which they are naturally accustomed.

(10) A factor that must be taken into consideration in investigating retention is the general attitude of the learner toward his work. If he is much interested in the problem in hand, and takes great interest in his task, he naturally takes more care and consequently is able to retain longer than another who has not this same feeling of interest. Where there is *zeal* and *desire* in learning, there follows an earnestness and interest in the work, which will eventually result in greater retentiveness. This is particularly noticeable in the tests on subjects who are working in psychological laboratories and therefore interested in experimental psychology.

Group 2.—(1) With any given number of individuals, it may be stated as a general rule that they will differ more in the time they take to memorize than they will in retentive capacity.

(2) The students who stand highest in their various studies and who prove upon examination to be "the most intelligent" have, as a rule, the best memories. They not only learn more quickly, but they retain better.

(3) Those who employ logical associations and visual imagery in the memorizing of a series of words or nonsense-syllables recall them more slowly than do those who memorize in an *auditory* or *motor* manner. The latter type of subjects recall them easily and quickly immediately after the first learning—but forget them just as promptly.

(4) As a general rule it is best to memorize thoroughly before attempting to recall. When in doubt do not waste time, and form confusing associations by continuing the attempt, but consult the text immediately.

(5) In general, the women and girls do better in their initial learning than do the men and boys. In *retentiveness,* however, the men and boys are on the whole slightly superior, but this is not so for every material.

(6) The quickest learners tend to learn their material more *as a whole* than do the slower learners and this is invariably so with the *second learning.* The quick learner only divides his material into parts when he is totally unfamiliar with it.

(7) The quick learners tend more to employ *rhythm* in the learning of digits, nonsense-syllables, and words, than do the slow learners. If the element of rhyme or rhythm enters, it aids the ability to reproduce after learning. Those who learn by means of rhythm can somehow or other reproduce better than those who do not employ such methods of rhythm.

(8) The relation of quickness of learning to retentiveness depends on many factors, the most important of which are *method, material* and *interval.*

(9) A change in the interval does not affect different forms of material to the same degree.

(10) As to the relation of quickness of learning to retentiveness the most general statement that can be made is that those who learn quickly remember longest if the material is logical in character. Where the material is "illogical" and is memorized by "motor associations" so to speak, the converse is true. This however, has many exceptions, depending upon the method used. The exceptions are most notable in the case of nonsense-syllables and words (*v.* pages 41 to 46).

(11) By Method 1 the score obtained by the first half of the class is invariably better than that obtained by the second half.[1] The difference between the first quarter of the class and the last quarter is naturally even more marked. The difference is found to be greatest in th case of *prose* and least in that of *digits.* With *prose* we frequently find that the first quarter of a class of 24 will remember (by Method 1) half as much again as the last quarter.

(12) The experiments on school children show that girls from the years of 10 to 24 learn more quickly than boys of the same age. The results also show that the number of retained members of any series increases from year to year.

(13) There is a positive correlation between education and memory. Inmates of prisons and attendants in state-hospitals do not do as well as boys of 15 years of age. Education thus has much the same effect upon retentiveness as has age.

(14) With both nonsense-syllables and words the first syllables of a series is retained longer than those in the middle of the series.

[1] Excepting, in the case of two groups of subjects, the *digits.*

APPENDIX

SOME OF THE MATERIALS USED

The materials most used have been quoted in the text, pp. 22 ff. The following materials were used on some groups of subjects.

List of 20 digits: 6, 1, 5, 8, 2, 7, 5, 3, 9, 4, 7, 2, 5, 9, 3, 0, 8, 1, 6, 2.

As presented for study, this list was arranged in a vertical column, as were also the lists of nonsense-syllables and of words.

List of 12 nonsense-syllables: LEV, DUT, NIV, POZ, DIB, FEG, ZAD, TOB, KED, BUP, KIF, RUZ.

List of 20 words: BIRD, RUG, EAR, SLATE, CAP, DOOR, BOX, TREE, CORN, AXE, SAIL, HINGE, BUG, SPOOL, DOG, BOOK, POST, GUN, BEAN, LAMP.

Poem

To see a man tread over graves
  I hold it no good mark;
'Tis wicked in the sun and moon,
  And bad luck in the dark.

You see this grave? The Lord he gives,
  The Lord he takes away:
O Sir! the child of my old age
  Lies there as cold as clay.

Except that grave, you scarce see one
  That was not dug by me!
I'd rather dance upon 'em all
  Than tread upon these three!

Ay, Sexton! 'tis a touching tale!
  You, Sir, are but a lad;
This month I'm in my seventieth year,
  And still it makes me sad.

PASSAGE APPROXIMATELY OF 100 WORDS FROM E. MACH

The present study of the monistic philosophy is intended for thoughtful readers of every condition who are united in an honest search for the truth. An intensification of this effort of man to attain a knowledge of the truth, is one of the most salient features of the nineteenth century. This is easily explained in the first place, by the immense progress of science, especially in its most important branch, the history of humanity; it is due in the second place, to the open contradiction that has developed during the century between science and the traditional "Revelation."

Passage of 160 Words from Kant's "Critique"

Time is nothing but the form of the internal sense, that is, of our intuition of ourselves, and of our internal states. Time can not be a determination peculiar to external phenomena. It refers neither to their shape, nor to their position, etc., it only determines the relation of representations in our internal state. And exactly because this internal intuition supplies no shape, we try to make good this deficiency by means of analogies, and represent to ourselves the succession of time by a straight line progressing to infinity, in which the manifold constitutes a series of one dimension only; and we conclude from the properties of this line as to all the properties of time, with one exception, *i. e.,* that the parts of the former are simultaneous, those of the latter successive. From this it becomes clear, also, that the representation of time is itself an intuition, because all its relations can be expressed by means of an external intuition.

Two Lists of Disconnected Sentences

1. From the Kingdom of Heaven those angels have come.
2. This horse ate nothing but oats.
3. The wise man seizes every opportunity.
4. Ten years had elapsed and they therefore crowned him.
5. From my own experience I know he will never achieve success in that line.
6. The farce entitled "The Telltale Coo" was written by Haljass, an author who lived in Venebaft.
7. The wise man is one who realizes the value of industry.
8. The laboratories here are so arranged that the room for psychological work receives the most sunlight.
9. The work executed in prisons and reformatories is quite frequently very well performed.

1. Opportunity comes both to the wise man and the fool.
2. The two wells met and the waters were dammed back.
3. We can say from Christ's teachings that God is Love.
4. I had dreamt that either rain or snow would fall.
5. Sin begets sorrow, as any knave can tell from experience.
6. The fairy thought that either son or daughter would suffice.
7. The school system is but one of our many failures.
8. A short time ago that nation was rich and prosperous.
9. From his writings we considered him a man who smoked.
10. "Waste not, want not" and "Grain in the morning sow."

As may be noted, the sentences are not only peculiar, but many of them are awkward. Many of them come from old Hindu fables, the awkward translation being desirable for the experiment in question.

"A Book of Commanding Importance"

Professor John Dewey,of Columbia University of New York, writes as follows concerning Mr. Bertrand Russell's recent book **Our Knowledge of the External World as a Field for Scientific Method in Philosophy:**

"There are many ways of stating the problem of the existence of an external world. I shall make that of Mr. Bertrand Russell the basis of my examinations, as it is set forth in his recent book **Our Knowledge of the External World as a Field for Scientific Method in Philosophy.** I do this both because his statement is one recently made in **a book of commanding importance,** and because it seems to me to be a more careful statement than most of those in vogue."

Professor Bernard Bosanquet speaks of the same book, **Our Knowledge of the External World as a Field for Scientific Method in Philosophy,** as follows:

"This book consists of lectures delivered as Lowell Lectures in Boston, in March and April, 1914. **It is so attractive in itself, and its author is so well-known,** that I think by this time it may be taken as read, and I may offer some discussion without a preliminary abstract."

It is admitted by scholars, both in England and America, that Bertrand Russell's book, **Our Knowledge of the External World as a Field for Scientific Method in Philosophy,** is the book of the year.

Note. This book appeared simultaneously in Great Britain and America, brought out by The Open Court Publishing Company of Chicago and London. Unfortunately, by some mistake, the book was published under two titles. In England it is given its full title, while the American edition has the shorter title, **Scientific Method in Philosophy.** The two editions are identical, and it is a little unfortunate that this mistake was made. The second American edition will be brought out under the same title as the English edition.

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THE OVERCOMING OF DISTRACTION AND OTHER RESISTANCES

I

BY

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PREFACE

In the spring of 1913, the writer of this monograph began some minor investigations concerning the effect of disturbances of various sorts upon mental work. These preliminary experiments led to the attack of the problem on a broader basis. The quality and quantity of the work done in the first experiments showed little or no effect from the disturbances, but before concluding that such disturbances were entirely uninfluential we determined to give the thing a more thorough test. The apparatus used in the beginning required a short intermission between each minute of work; a new mechanism was therefore devised that would permit constant work for an indefinite period. As the disturbances had been comparatively weak, it was decided to use as severe disturbances as could be gotten and then after we had discovered the effect of these to reduce the intensity. As will appear later, any reduction proved unnecessary and useless. Finally we determined if no effect could be discovered in the time and accuracy records to use any test available to ascertain if there was any effect at all from disturbing influences.

Such a test as we proposed required rather elaborate and very accurate apparatus and so we need make no apology for the somewhat lengthy and detailed description of it. Its construction occupied a period of six months, but after once completed was of such a nature that it gave perfect satisfaction and the records throughout are highly reliable.

After our work on the main part of the problem, experiments of a different nature were carried on to corroborate the conclusions reached. The apparatus for these was simple and will be described briefly in connection with the experiments. The work was completed in the fall of 1915.

It is with great pleasure that we acknowledge the advice and encouragement received from Professors Woodworth and Cattell and Dr. Poffenberger. We wish also to thank those who were so kind as to work as subjects under conditions that were far from inviting.

John J. B. Morgan.

Columbia University,
New York City.

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THE OVERCOMING OF DISTRACTION AND OTHER RESISTANCES

CHAPTER I

INTRODUCTION

I. *Statement of the Problem*

THE setting of a psychological experiment has always been of recognized importance. Since much of the technique of experimental psychology was taken bodily from the other sciences, especially physics, it was regarded as a truism from the start that the situation created for any experimental problem had to be kept as nearly constant as possible before the conclusions could have any claim of validity.[1] It did not take long to discover that in spite of the utmost precautions to maintain an invariable situation, even though these precautions far exceeded those required in other sciences, the responses of the human reagent exhibited an enormously greater variability. While mathematics has been used to take care of variability to a large extent and has enabled psychology to arrive at conclusions in spite of irregularities in response, still there has been an unceasing effort to sift down the causes for this variability.

At first these variations were divided into groups according to the influences exerted by the supposed faculties of memory, emotion, will, attention, and the like. Experimental psychology then sought for a more exact formulation of each of these concepts and has studied how each influences activity. In some directions experimentation has been more successful than in others, but even in those phases in which some success has been achieved, much still remains to be solved. One handicap to progress has been lack of agreement in definition, an example of which is the work on attention. It has been defined in a multitude of ways, and we seem as little near agreement now as ever. Experimental work instead of seeking to sift down facts has been used to support one theory or another.[2] The most recent investigations on the measurement of attention illustrate this. Geissler[3] and Dallenbach,[4] starting with the hypothesis that attention is sensory clearness, devise an experiment which shows a correlation between grades of clearness introspectively determined and accuracy of judgments; concluding from this that their hypothesis was correct, since the only way to measure clearness is introspectively, therefore introspection must be the only measure of attention. On the other hand Woodrow,[5] taking the hypothesis that attention is an equivalent to preparedness of the nervous system to react to a stimulus, shows a correlation between the length of the preparatory interval and reaction time, which by his definition is due to the amount of attention, and hence concludes he has a measure of attention.

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[1] Fullerton and Cattell, "On the Perception of Small Differences," 1892, p. 152.

In this investigation we have no theory that we wish to demonstrate, we simply wish to investigate phenomena. Our endeavor will be to discover if possible the way in which a subject will react to irrelevant noises which are produced while he is engaged at some task. It is only a part of the problem which concerns the influence of the factors in a situation in which a reagent is placed upon his response. It is the question whether the stimulation of the sense organ of hearing will have any effect upon the performance of a task which requires in no way the use of this particular organ.

A problem need have no direct practical significance in order to be of value to science, to be of interest to the scientist, or to be worthy of investigation; but if it has practical importance it is in no wise discredited thereby. Every reader will see at once the importance of the problem of the influence of irrelevant noises upon mental work. We all know that in the reading of a peculiarly interesting book we can become entirely oblivious to every thing about us, even to severe noises. But not one of us will seek a particularly noisy place to take our reading, no matter how interesting it may be. When we enter a reading room we are confronted by the sign, "SILENCE." If we have some hard mental task, noise becomes really distasteful to us. It is then an important problem to determine just what the effect of a situation replete with irrelevant noises is upon our performance. If it is merely a foolish fancy with which we are obsessed when we desire quiet, it is well that we know it. If noise is a hindrance, can it be overcome? If so, at what cost? These and many other questions are worthy of solution. We may not answer all or any of them, but our problem is to make an attempt to do so.

---

[2] For theories of attention see:

Hamlin, A. J., "Attention and Distraction," *Amer. Jour. of Psychol.*, 1896, *8*, 3–66.

Dürr, E., "Die Lehre von der Aufmerksamkeit," Leipzig, 1909.

[3] Geissler, L. R., "The Measurement of Attention," *Amer. Jour. of Psychol.*, 1909, *20*, 473–529.

[4] Dallenbach, K. M., "The Measurement of Attention," *Amer. Jour. of Psychol.*, 1913, *24*, 465–507.

[5] Woodrow, H., "The Measurement of Attention," *Psychol. Rev., Monograph Suppl.*, 1914, *17*, pp. 158.

II. *The Method.*

The method of procedure in such a problem as this is a very important consideration. Ordinarily where it is desired to find the effect of a certain condition or circumstance upon a subject's performance, tests are made under normal conditions and compared with the results of tests made under conditions where the factor under investigation is included. If the factor has any effect it will be shown, so the supposition is, in the results. Absence of difference in the amount of work done correctly, in equal time intervals under different conditions, shows that the factor has no influence upon the task. Such conclusions are possible only on the assumption that the subject does his best in both cases. Although this is not plainly stated by some writers, it is tacitly assumed; by others it is boldly stated. For instance, Thorndike says: "In ordinary mental work one does not work throughout at one's possible maximum, so that a spurt is easily possible. In experimental work, when the subject is required to work throughout at maximum possible efficiency, such a spurt can come only if the subject has deliberately disregarded instructions, or if the knowledge of the approaching end releases forces over which he had no control. The latter is apparently possible, various external stimuli, such as other competing individuals, applause and the like, being apparently able to add a reinforcement beyond what a subject's own determination can summon."[6] While in the last statement he admits the possibility of being spurred beyond one's apparent best, he (as well as others who have worked on this line) ignores this consideration in experiments upon which it might have a large bearing.

We too went to work with this assumption, that a subject's best under one set of conditions equaled his best under other conditions. Our main experiment is a rigid test of this assumption and it seems from our results that it is wholly unwarranted. A subject is never working to the last notch, and if the proper incentive comes it is always possible for him to work harder. The way in which the ordinary experiment on the effect of some factor upon work is conducted is somewhat thus: The subject under normal conditions is assigned a certain task which he does at his best; the factor to be tested is then introduced and the subject works again at the same task; the factor is then removed and another test made under normal conditions. The subject is more or less aware of the change in the conditions. If he is fully aware of it he deliberately sets about to combat it, endeavoring to show the experimenter that such a thing cannot bother him. If he is not aware of it directly, he is conscious that the work proceeds with greater difficulty; which, with the consciousness that he is being tested, makes him put forth unusual effort to do as well as he did before. We do not state this as a presupposition to work upon, but as a result that has appeared from this experiment. We state it in the introduction so that the reader will more readily grasp the significance of the results of the first experiment.

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[6] Thorndike, E. L., "The Curve of Work," *Psychol. Rev.*, 1912, *19*, 173.

III. *Historical*

Much of the work that has been done on this line has been in connection with the problem of attention. Some work has been done with rhythmical sounds, but as we have endeavored to exclude rhythm we are not directly concerned with this. Since noises have been used in efforts to measure attention by the "distraction method", any review of the work on the effect of noise will take us into the literature on the measurement of attention, and hence will be more or less involved in theoretical problems. As a complete history of this problem may be found elsewhere,[7] we will limit our account to the work that bears directly on our problem, that of noise or sound disturbance.

1. *Noise and Reaction Time.*

As early as 1874 Wundt[8] had studied the effect of noises upon reaction time. He continually revised his statements and the report he gives in the later editions of his work may be taken as fairly expressing his conclusions. He thinks that the disturbing stimulus may be in the same sense field as the stimulus to which the reagent is to react, with the condition that there must be a clear distinction between the two, so that no confusion can arise, and one be mistaken for the other; or it may be in a different sense field. This condition which he lays down, though evidently essential, has not been always borne in mind, as our treatment of later investigations will show. He also shows that the order of presentation of the disturbance and reaction stimuli is important. As the following figures submitted by him show, if the disturbance comes with or after the signal stimulus, the result is as though there was no disturbance. If the disturbance comes before the signal the reaction time is always lengthened.

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[7] Geissler, L. R., "The Measurement of Attention," *Amer. Jour. of Psychol.*, 1909, *20*, 473–529.

[8] Wundt, W., "Physiol. Psychol.," 4th revised ed., 1893, pp. 353–358.

SOUND EXPERIMENT

	Median	Max.	Min.	A.D.
Disturbing noise with or after signal	176σ	237σ	140σ	*8*
Disturbing noise before the signal	228σ	359σ	159σ	*12*

LIGHT EXPERIMENT

	Median	Max.	Min.	A.D.
Disturbing noise with or after signal	228σ	284σ	158σ	*17*
Disturbing noise before the signal	250σ	291σ	212σ	*23*

His figures indicate much more disturbing effect when a noise disturbance is used with a sound reaction stimulus than when a noise disturbance is used with a light reaction stimulus. This seems to emphasize even to a greater degree his statement that there must be a clear distinction between the disturbance and the stimulus used.

Obersteiner,[9] experimenting on one individual only, found a prolongation in reaction time due to the effect of a music box playing "softly" in the vicinity of the subject: The normal time of this subject was 100 sigma (A.D. 11 sigma), with noise disturbance it was 141.5 sigma (A.D. 16.6 sigma). Even if it could be shown that his technique and procedure were faultless his figures would demonstrate nothing since he had but one subject and that one evidently not normal in his reactions.

Cattell,[10] making experiments on reaction using different distractions, found that sound did not act as a distraction. His explanation of this fact is that "reaction is an automatic act, only needing the activities seated in the cortex to prepare its way. A noise did not . . . so disturb the subject as especially to interfere with the placing in readiness of parts of the brain concerned in making the reaction." He explains the disparity of Wundt's results with his own on the basis that Wundt's subjects in all probability had not learned to make the reactions automatically.

Over against Cattell's work stands that of Swift.[11] His procedure is more like that of Cattell than like that of Wundt. Both he and Cattell used metronomes for disturbances, while Wundt used a single sound coming at a certain period in relation to the stimulus signal. Although they used the same disturbance and somewhat the same clangs to be compared. His results were negative. He found no definite difference between judgments with and without disturbances. His conclusions have more of a theoretical bearing on the problem of imagery than on that of disturbance by noises.

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[9] Obersteiner, H., "Experimental Researches on Attention," *Brain*, 1879, *1*, 447–8.

[10] Cattell, J. McK., *Mind*, 1886, *11*, 237–242.

[11] Swift, E. J., *Amer. Jour. of Psychol.*, 1893, *5*, 5–17.

Geissler[19] used noise among other disturbances in an attempt to measure attention in terms of clearness, using as a task visual discriminations. He concludes that even the "most complex combination of distractors after a few days work were unable to induce great variations of attention. Instead toward the end of the whole group, most of the normal series were actually performed at a slower rate than the distraction series."

Dallenbach[20] followed Geissler's experiment using, instead of visual discrimination, auditory discrimination. Neither experiment was of a nature to discover with any accuracy the effect of noises. The procedure consisted in producing various conditions of disturbance while the subject was doing the assigned task, a record being taken in terms of time (or amount done) and of the accuracy of the performance. Then after each experiment an introspective measure of the clearness of the content discriminated in the experiment was obtained. Finally a correlation was calculated between this clearness scale and the speed and accuracy of the work, and because this correlation was rather high the conclusion was drawn that the true measure of attention is a subjective scale of clearness. Such a conclusion presupposes that the amount and precision of the work was influenced only by changes in attention. This could not be known unless all practise, fatigue and feeling factors were eliminated. But supposing that the experimenters had eliminated all these (which they certainly did not), why not take the amount and precision of the work as a measure of attention directly and not by a roundabout procedure, involving endless difficulties, adopt a measure which is from the very nature of it much less precise? Dallenbach used the distractions to procure changes in the performance of the subject but since he finds no definite correlations he concludes that disturbances have no reliable influence. An inherent difficulty prevents him from giving any precise answer as to the effect of the disturbing noises. In an earlier section we called attention to the fact that Wundt lays down the rule that if the disturbance is in the same sense field as the task it must be of a distinct sort. Dallenbach's task was to note the point of time and rapidity of changes in pitch and intensity of a tone made by a Stern variator, at the same time using as disturbances, sounds varying from a metronome to a graphophone. Inaccurate judgments in such a situation would, in some cases at least, arise from confusion, the confusion would cause a report of a low degree of clearness, and of necessity the confusion would also cause a poor score. The correlation between clearness and precision would thus be increased and of course help in the endeavor to show that clearness is the measure of attention.

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[19] Geissler, L. R., "The Measurement of Attention," *Amer. Jour. of Psychol.*, 1909, *20*, 473–529.

[20] Dallenbach, K. M., "The Measurement of Attention," *Amer. Jour. of Psychol.*, 1913, *24*, 465–507.

In conclusion: It is probable that reaction time that is not automatic is lengthened by noise disturbance, automatic reaction times not being affected.

Of the effect of noise disturbances on higher mental processes, all that can be said is that there is some evidence of a dynamogenic effect, the stimulation of one sense organ facilitating the functioning of another. This conclusion however is not universally accepted,[21] and needs further evidence.

IV. *Outline of the Experiment*

From the results of the work upon the effect of noise it seems evident that certain methods are unproductive. The study of its effect upon judgments of various sorts has been very uncertain and irregular, due perhaps to the fact that the judgments can be made in the intermittent period of any disturbance that is not absolutely continuous. The results also show that any task which could be made automatic by practise is unsuited for use in an experiment to ascertain the effects of any disturbing influence.

We therefore endeavored to get some test which could not be practised to the point where it would require no cerebral direction, and which yet had little practise effect. The card sorting test seemed a good one for the purpose,[22] but had the disadvantage that it did not permit of accurate measurement. An arrangement was consequently devised that would require a similar task but one which could be measured. It was planned to have ten different letters (or numbers) exposed in a chance order as fast as the subject could react to them and in an endless series. His response consisted in pressing a key corresponding to the letter or number seen. These numbers were arranged on the keys numerically so as not to require the learning of their position, since everybody is familiar with the sequence 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. As the subject was told to react always with the same finger, the correlating of a certain

[21] Binet, A., *L'Annee Psychol.*, 1900, *6*, 562.

[22] Jastrow, *Psychol. Rev.*, 1898, *5*, 297. Seashore, C. E., "The Psychergograph," *Studies in Psychol. Univ. of Iowa*, 1902, *3*, 1–17.

number with a particular finger was eliminated and we had a simple procedure which could not be learned and which required the same process the last time it was made as it did the first. One must look at the exposure opening to see what number was exposed, look at the keys and select the proper one and react with the first finger of the right hand. The order was so varied that it could not be memorized, and the subject kept busy for an indefinite length of time.

While he was thus busy noises were introduced and as each response of the subject was being recorded the exact effect of this noise was measured. The subject was placed alone in a room and was not disturbed by the experimenter or by any machinery. The only machine in the room consisted of the exposure apparatus, which worked only at his touch of one of the keys.

Various procedures, tried in an effort to eliminate irregularities, will be described in order to show the comparative merit of the one used in the later experimentation. It was found advisable to take other records besides those of speed and accuracy, for reasons which will appear as we progress with the report.

Great care was taken to have the apparatus in good working order.

The majority of the subjects knew nothing of the nature of the experiment, or of experimental psychology. They were brought in from outside or from other departments of the university through the assistance of friends. They were placed in the room, instructed how to react to the stimuli and left to themselves. They were told that records were being taken of their speed and accuracy, but they knew nothing about the noises that were to be introduced. Our object was to see how a naive subject would react to a certain situation. Several trained subjects were also used, none however trained in this particular experiment.

CHAPTER II

APPARATUS

An important condition to the successful conduct of an experiment such as the following consists in properly designed and constructed apparatus. In order to make clear this fact a brief description of the nature of the procedure of the experiment might not be out of place here. It was desired to have the subjects alone in a room seated before an exposure apparatus which would present to them material in varied order and just as fast as they could respond to it. The subject's response to these presentations would consist in pressing one of a number of keys, which must be connected with a recording apparatus that would register both speed and accuracy of response. Furthermore, it was required that the task be so designed that the subject should be kept at work for a considerable length of time. During the course of the experiment disturbances were to be introduced and all these would have to be arranged so as to be controlled from outside the subject's room.

I. EXPOSURE APPARATUS

Probably the most important instrument in such an experiment as this is the exposure apparatus. It was necessary, (1) that each exposure remain in place until the subject responded, and that this response cause the immediate appearance of the next exposure, which would in turn remain until responded to by the pressure of the corresponding key. (2) In the second place it was necessary that the series be of such a length and arrangement that though it was repeated the subject would not be able to memorize the sequence. (3) It must make little noise. It was not considered that it must be absolutely noiseless in the same sense as a visual exposure in reaction time work, but there must be no noise except the click at the pressure of the key. (4) It must respond easily and quickly, (5) and finally it must work every time.

There are a number of commercial instruments which expose material at regular intervals. With such an arrangement the subject must react just as quickly as the exposures appear or he will make omissions which must be counted as errors. It was desired to get the record as largely as possible in terms of time, and this could only be done by allowing the subject to set his own pace and designing an instrument whose speed of action would depend upon the speed of his response.

A typewriter has been adapted to meet such requirements.[1] It however was not entirely suitable for the present investigation. It gives only a short series, which is repeated each time the carriage is shifted. Since it begins at the same point this series may be readily memorized, in part at least. Besides it was not suitable for obtaining a record of the pressure exerted upon the keys, without elaborate changes, and since we planned to take this record we discarded the typewriter for something more suitable. The writer worked with a mechanical apparatus in some previous investigations, but found that it did not work as easily as was desired. If the action of the instrument depends upon the proper striking of the key, as a mechanical one does, it fails to work at times, for different subjects strike the keys in different ways.

The only other hopeful type is the electrical. Of these a number have been designed and used, most of which however have a type of movement that makes their action uncertain. The operation of this type consists in a lever (*B*) operated by an electro magnet (*A*), working on a notched wheel (see Fig. 1). The movement of the lever toward the magnet turns the wheel one notch. It is stopped either by a spring (*D* and *F*) bearing upon the notched surface at another point, or some similar device. When the current

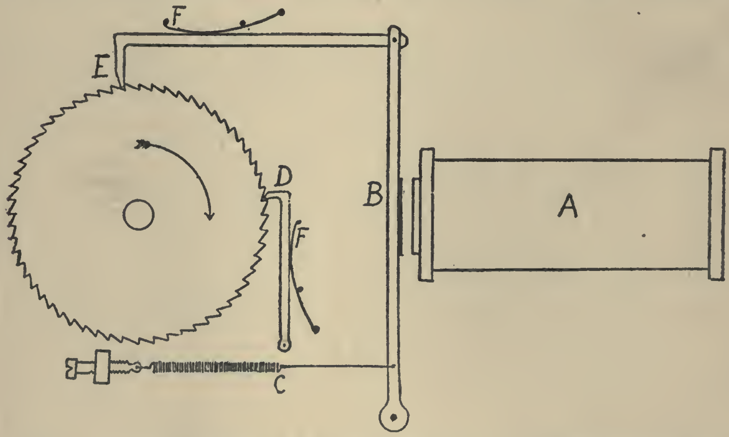

FIG. 1. Sketch designed to show the principle of an unsatisfactory exposure movement. *A*, electro-magnet; *B*, armature; *C*, spring to pull the armature back to place after it is released from the magnet; *D*, catch to hold wheel in position until moved by catch *E*; *FF*, springs to hold catches in place.

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[1] Bair, J. H., "The Practice Curve," *Psychol. Rev. Monog. Suppl.*, *19*, 1902, 15.

through the magnet is broken a spring (*C*) pulls the lever away from the magnets, allowing *E* to engage a new notch. It may be arranged in one of two ways; the wheel may be turned when the lever is pulled toward the magnets, the spring serving to pull the lever back into place and engage a new notch; or it may be reversed and the magnet pull the lever so as to engage a new notch, and the breaking of the current allow the spring to turn the wheel. Whichever method is used the difficulty is the same and it is this: The disc or cylinder, or whatever it is that must be turned in order to expose the material weighs something, consequently there is a certain inertia to be overcome in starting it and momentum to be overcome in stopping it. The adjustment of current strength, spring tension, and the device used to stop the wheel, so that they all work properly and work every time is a well-nigh hopeless task. Either the momentum will at times carry the cylinder two or three notches instead of one, or the inertia will keep it from responding at all when the spring is tight enough to overcome the first difficulty. This principle is however used very successfully in the electric counter of the Hollerith electric tabulating system because the only weight to be moved is that of the hands of the counter.

A type of movement that will allow considerable weight to be moved a certain distance and stopped quickly, that will work accurately and work every time in perfect response, is the escapement movement. It is in successful commercial operation in all clock works and typewriters, which is of itself sufficient recommendation for it. The apparatus used in this experiment was constructed on this principle, and to encourage its use in laboratories it may be said that once built it worked without fail through the entire experiment requiring no attention or readjustment.

Now for a more detailed description of it. An old clock work was used. In place of the hands was substituted a cardboard disc on which could be placed the material to be exposed. A different wheel from the one used as the escapement wheel had to be used so as to turn the disc far enough at each escapement. With this change the fundamental part of the exposure apparatus was complete. A simple sketch of the mechanism is shown in Fig. 2.

When the current is closed through the magnet (*A*), the armature (*B*) is drawn up, allowing one tooth of the escapement wheel to pass the side of the engaging lever against which it is resting, the wheels being propelled by the mainspring of the clock; the other side of the engaging lever (*E*) comes in front of another tooth however before the first one has been released, thus allowing the wheel to move only a given distance. When the circuit is broken the spring draws the armature back to its original position, one side of the arm catching one tooth before the other side releases its tooth. It can be readily seen that it is simply a matter of accurate construction to make an apparatus of this nature that will accurately perform for an indefinite period of time with little or no attention. The one used will give five thousand exposures with one winding.

The disc used in connection with this mechanism made a complete revolution in sixteen complete movements of the magnet armature. It was thought that this series was not large enough, and so the cardboard placed in front of the disc to cover all but the letter to be exposed, was made to move in a horizontal direction. This movement allowed different circles of the disc to be exposed.

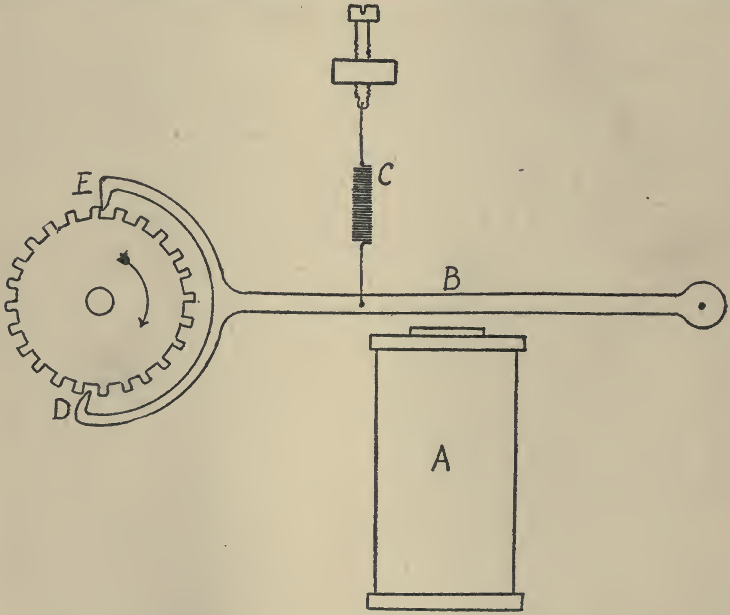

Fig. 2. Diagram of the escapement movement. *A*, electro-magnet; *B*, armature; *C*, spring which pulls the armature from the magnet when the current is not flowing; *D* and *E*, catches engaging the teeth of the gear wheel. When the armature is pulled away from the magnet the catch *E* releases its gear and catch *D* engages one on its side. When pulled to the magnet *D* releases its hold and *E* again engages.

Different circles of letters were arranged upon the disc and so a large series procured. This movement was made by the operation of an electric current upon an electro magnet, which current was closed automatically once upon each revolution of the disc. The opening occupied four different positions. If, for example, at first it occupied the extreme left position, the next move would be to the right, the second to the right, the third to the right again, the fourth would be to the left, the fifth to the left, and on the sixth it would occupy the position it did at the start. Its movement then was like that of a shuttle with however two stopping points between the extremes. There were to correspond four rings of letters upon the discs behind the screen. If the rings were numbered from one to four from the inner ring to the outer they would be exposed in the following order, 1, 2, 3, 4, 3, 2, 1, 2, 3, 4, 3, 2, 1, etc. The series would be repeated but in different orders, and as the subjects did not know the operation of the apparatus they had no definite starting point from which they could learn the series.

Furthermore, it was desirable that the task of the subject be varied. Instead of the simple task of seeing one of a series of letters or numbers and reacting by pressing a corresponding key, it was deemed advisable to complicate the task somewhat. This was done by the use of codes. For instance the letter Z might be exposed; by means of a code placed before the subject this letter would be translated to *A*; looking to another code he would translate *A* to a 2, and react by pressing key number 2. Several of these methods were used and will be described fully in discussing the experimental procedure. It is simply desired here to show the relation of these codes to the construction of the apparatus.

If such codes had been arranged and placed before the subject he possibly could have memorized the codes during the work. To avoid this a device was included for changing the codes, which device is shown in Fig. 3. One pair of magnets (*J*) was in series with key number two of the reacting keys (there being ten in all), and the other pair (*K*) were in series with key number seven. As the subject worked he would press each of these keys in their turn and thus magnetize one or the other of the magnets. If the current passed through one pair (*K*) it would release the catch (*L*) and the spring (*M*) would pull the arm away from the second pair of magnets (*J*). If the current passed through the second pair (*J*) the armature would be drawn up and held by the catch (*L*). If the arm were already engaged in the catch and the second pair of magnets received the current, it would not move. By this arrangement the arm had to be either at one end of the movement or at the other end. This was very desirable. The paper strip containing the shifting letters must always be in a position to show one code or the other. A device that would not insure this would be unsatisfactory, as it might move halfway and thus either confuse or even stop the subject's work. It could not happen with this arrangement. In brief then, the code consisted of a card containing a row of letters beneath each one of which was an opening. Behind these openings another card was moved by the magnets, at each move bringing to view a new set of letters and thus changing the code.

To sum up, the working of the apparatus is as follows: Upon every reaction of the subject the exposure disc turns one sixteenth of a revolution, bringing to the opening a new character; every sixteenth reaction the opening shifts, thus presenting a new circle of characters; and when certain of the reaction keys are pressed the code, by which the characters are translated, is changed.

II. Reaction Keys

The keys upon which the subject were to react were ten in number. They were about the size of typewriter keys and placed in one row, spaced the same distance as typewriter keys. Each key was supported upon a bar six inches long. This bar was pivoted at the center and at the end opposite the key was fitted with a spiral spring which drew the key back to place after each reaction. This spring could be given more or less tension by means of a screw, so that all the keys could easily be made to respond to the same pressure.

Various types of contacts were tried before a successful one was obtained. It was found that any type of simple touch contact was not satisfactory because if the subject made a quick response a good connection was not always made. The success of the experiment demanded that every time a key was pressed, no matter in how careless a manner, contact should be made. Mercury contacts were the only ones that could be made to do this. A point from each key, when pressed, entered into a mercury trough. The mercury in the trough was covered with oil so as to eliminate any sparking of the contacts. All the attention that these keys needed in order to insure perfect work was the occasional removal of the old oil and its replacement by a new supply. The keys were tested from time to time to insure proper adjustment of the tension springs.

III. Pressure Recording Device

One reason why the keys had to respond perfectly to every reaction was that it was planned to take a record of the pressure exerted upon them by the subject in his reactions. This was accomplished by means of the following device. All the keys were mounted on one block of hard wood. The rear edge of this block was mounted in turn on hinges and the front supported by a spring which was sensitive enough to respond to the lightest touch, and yet stable enough not to allow a rocking of the board after a reaction. Fastened to the board was a rod which was connected to the diaphragm of a Marey tambour. This tambour was joined with another which made the record in an adjoining room. This scheme worked so well that the lightest touch, even too light to move one of the keys (which worked with very light pressure), made a record, and yet with so little vibratory movement that not one of the subjects, when questioned after the experiment was finished, stated that he had discovered that there was a mechanism connected with the keys to take a pressure record.

IV. Breathing Record Apparatus

The breathing records were taken by means of a pneumograph connected with a recording Marey tambour. It consists simply of a three quarter inch spiral spring enclosed by a flexible rubber tube which is closed at each end and connected with a rubber hose leading to the recording tambour. Any movement of the body around which it is placed changes the volume of air enclosed in the tubing and makes a record.

V. Recording Apparatus

(*a*) *Time and Accuracy Records*

The graphic method was used throughout the experiment. Connected with each reacting key was a separate electromagnet which operated a recording armature. All the keys were also connected through a single magnet, so that when any one key was struck it operated its special magnet as well as the one common to all. Recording by the side of this common magnet was another connected through a Jacquet time clock, recording once every second. Another magnet was connected with the keys used to put into operation the disturbances used in the experiment, and another to record the shifting of the exposure opening.

These fourteen magnets all recorded side by side by tapping a typewritter ribbon against a continuously moving paper. The paper was turned over a drum by means of an electric motor. The motor also operated a device which turned slowly the typewriter ribbon.

By means of this record the time and accuracy of the performance could be obtained. The record contained, side by side, the time line in seconds, the disturbance record, the reaction time record, and the records of the individual magnets, which gave the accuracy score. The experimenter had a table of the series of exposures as they would appear, and thus could detect erroneous reactions in the record. This whole mechanism worked automatically and after it was once started needed only to be watched to see that nothing went wrong; it allowed the experimenter to give his time to the operation of the disturbances and of the kymograph used for the breathing and key pressure records.

(b) *Breathing and Key Pressure Records*

The breathing and key pressure records could not be recorded on the same sheet as the speed and accuracy records, since they required smoked paper. A simple clock-work kymograph was used for these. A sufficient supply of smoked paper was prepared beforehand to take the records for a full sitting of an hour or longer. On the drums were three records: (1) the time line procured electrically by the same Jacquet clock that made the time line on the continuous roll kymograph; (2) the breathing record; (3) the record of the pressure exerted upon the keys at each reaction.

A few breathing curves and a few key pressure records were lost each time a drum was changed, but these were only a small percentage of the total number and their omission does not distort the data obtained.

VI. Disturbances

It will be difficult to convey to the reader an adequate idea of the disturbances used in this experiment. An effort was made to have them severe enough to compare with those which one meets in daily life, and it may be said without the least exaggeration that they were much more severe than any which one meets under ordinary circumstances. Only sound disturbances were used. The first set were a group of noises which in actual work were always used together, changing continuously from one to another. This set comprised nine different sources in various parts of the subject's room, which was eighteen feet long, thirteen feet wide, and fourteen feet high. Their severity can be better appreciated if it is remembered that they were in a closed room of this size. They were:

1. A fire bell with an eight-inch gong, directly behind the reagent and eight feet away.
2. A bell mechanism with the gong removed and the hammer striking against a resonance box, placed behind the subject to the left.
3. Another bell mechanism with the hammer vibrating against a metal beam which ran the whole length of the room.
4. A bell hammer vibrating against the table where the subject sat.

5. A buzzer placed upon the subject's table.
6. A bell to the left in front of the subject.
7. A bell behind the subject to the right.
8. A buzzer on a tin box under the table where the subject sat.
9. A buzzer on the left wall on a resonance board.

All these were connected electrically with keys in the experimenter's room and were operated from there.

Besides this set of noises a graphophone was used. The machine was set up in the experimenter's room and connected through the wall to the horn in the subject's room by a metal tube. Metal was used to insure full transmission of the sound. The records used were six in number. Two were vocal solos, two were instrumental selections, and two were humorous speeches. In detail they were:

1. "Killarney." Tenor solo.
2. "Sentinel Asleep." Bass solo.
3. "Amoureuse Waltz." Concertina solo with orchestra.
4. "The Swiss Shepherd." Ocarina solo with orchestra.
5. "The Liars, or My Uncle's Farm." Two negroes talking.
6. "How Mother Made the Soup." Monologue.

VII. Wiring

The wiring of the complete apparatus[2] is shown in Fig. 3. Since this diagram embraces six independent circuits, for the sake of clearness it will be necessary to trace each one separately.

1. *The Signal Lamp Circuit*

Two sixteen candle power lamps (*A* and *B*) were placed behind, one over each shoulder of the subject, as he sat facing the apparatus. These were in addition to the lighting of the room, which was a single light in the middle of the ceiling. Since he worked in a dark room the subject could not see the exposure apparatus until the two lights behind him were lighted. These served then as an admirable signal for him to begin and end his work. They were operated by a key (*C*) in the experimenter's room, as may be seen in the diagram.

2. *The Reaction Circuit*

As soon as the signal was given the subject reacted to the letter already exposed. This he did by pressing one of the keys (*D*). This closed a circuit which passed from the positive side of the battery source (E.M.F.) to the magnet (*F*) which operated the exposure apparatus (*G*), through this magnet to the mercury trough common to all ten of the subject's keys (*D*), through the contact to the cable and thence to the recording magnet corresponding to the key pressed, then to the recording magnet (*H*) common to all, and finally through an electric counter (*I*) to the negative side of the battery source. The pressing of any one of the reaction keys thus did several things. It operated the exposure apparatus, bringing a new letter to view, it operated also the recording magnets and an electric counter.[3] As soon as he could the subject looked at the letter which his first reaction had brought to view and reacted to it, and so on as long as the lights were turned on.

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[2] The graphophone of course had no electric connections so that the experimenter marked on the record the beginning and ending of each performance of this instrument.

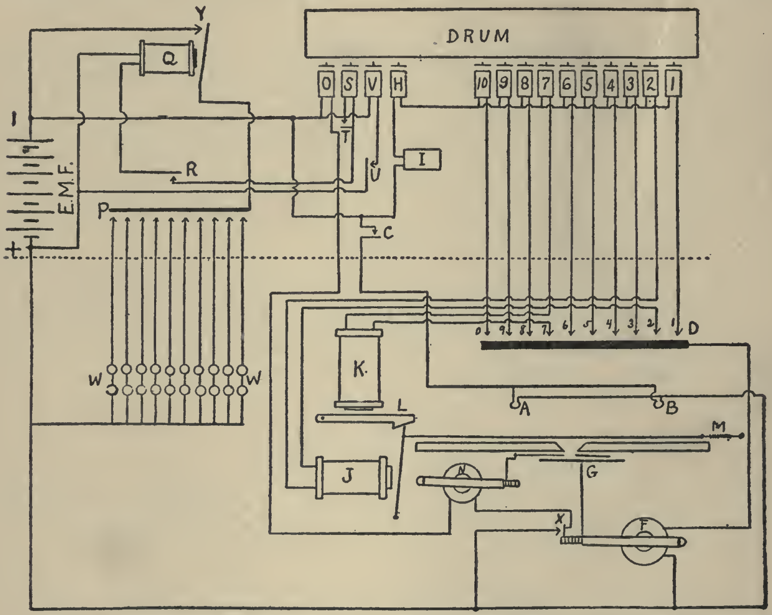

FIG. 3. Wiring of the apparatus. The dotted line represents the division between the two rooms, the lower half being the subject's room and the upper part the experimenter's. All electric contacts are represented by arrow points. Where one line passes another without making contact one of the lines makes a semicircle over the other. Where two lines meet squarely it means that they are connected. Only one battery source is shown (E.M.F.) in order to make the drawing clearer. As the circuits required currents of different strengths different sources were used, and various resistances inserted where needed. *N* and *F* are magnets operating devices whose principle of operation is similar to that of Fig. 2. The detailed explanation of the circuits will be found in the text.

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[3] This record was not used in tabulating the results. These were all taken from the graphic records. It simply served to show the experimenter how many reactions the subject had made at any point in the experiment, and guided him in the administration of the disturbances.

3. *Code Circuit*

If the key which he pressed happened to be number two, the current before going through the cable to the other room passed through one of the magnets (*J*), working the slide which changed the code. If it happened to be key seven it went through the other magnet (*K*) of this mechanism before entering the cable and changed the code in the other direction.

4. *The Screen-shifting Circuit*

Furthermore, when the disc of the exposure apparatus made a complete revolution it closed another circuit (*X*) from the positive side of the battery source through the magnet (*N*) shifting the exposure opening and through the recording magnet (*O*) back to the negative side of the battery source. This served to expose a new circle of figures or letters on the disc.

5. *Disturbance Circuits*

All the above connections were effected through the reactions of the subject. The noises (*WW*) were operated by the experimenter. Each of the noises was connected with a key and all of these keys (*P*) were connected through the contacts of a relay (*Y*). To operate a noise the experimenter closed one of the noise keys and then pressed another key (*R*) closing a circuit through the recording magnet (*S*) for noises and the relay (*Q*). This closed the relay contacts (*Y*) and set the noise into operation. In the experiments where noises were kept going continuously, as this arrangement would keep the recording magnet drawn up continuously, another key (*T*) was used to short circuit the recording magnet (*S*) and thus release the recording armature, while the relay armature (*Q*) would still be drawn up. Before the noise was stopped it was again opened, allowing the magnet to record, and thus the points where the noise began and ended were marked.

6. *The Time Line Circuit*

The time line was a series of dots on the paper a second apart. It was made by a current passing from the positive side of the battery through the Jacquet time clock (*U*) the recording magnet (*V*) to the negative side of the battery.

CHAPTER III

EXPERIMENTS WITH TIME AND ACCURACY RECORDS

I. *A Comparison of Several Tasks*

1. *Description of the Tasks.*

THE first problem attempted was to find the comparative value of several tasks, in order to see whether the noises would have a different effect as the task became complicated. Four tasks of varying difficulty were tried, all of which could be used in connection with the apparatus described in Chapter II. The ten keys were numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. The exposure apparatus was arranged to expose these ten numbers in chance order. In the simplest task the subject looked at the exposed letter and pressed the proper key with the first finger of the right hand.

In the second task the first ten letters of the alphabet were exposed in chance order. The subject after perceiving the exposed letter looked at a code, translated the letter to a number, and then pressed with the forefinger of the right hand the key corresponding to this number. The code was changed by the apparatus described above and so could not be memorized. The upper unchangeable part of the code consisted of the letters arranged alphabetically, while below each letter a number was exposed.

In the third task the exposures comprised the letters L M N P S T V X Y Z. Two codes were used, both being changeable. The first code consisted of an upper row with the letters L M N P S T V X Y Z and the lower the first ten letters of the alphabet in chance order. The second code had the first ten letters of the alphabet on the upper row, and numbers on the lower. The subject translated the letter from the lower end of the alphabet to one from the upper and then this letter to a number, which told him which key to press.

The fourth task was still more complicated. In this task the letters L M N P S T V X Y Z were exposed upon backgrounds of one of the three colors; red, yellow, or green. Below the exposure opening was a changeable code where the letters were to be translated to one of the first ten letters of the alphabet.[1] Above the exposure opening were three codes, one red, one yellow, and one green. Each of these codes had an upper row consisting of the letters from the beginning of the alphabet, beneath each of which was one of the numerals used on the keys. In this last task the subject had to look at the opening, note the color as well as the letter, look to the lower code and translate the letter to one of the letters A, B, C, etc., then look above the exposure opening to the code whose color corresponded to the color exposed at the opening, translate here the letter to a number and press the proper key, whereupon, as usual, the apparatus exposed a new combination to be reacted to.

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[1] After the first few experiments it was found that the letter I was confused with the number 1, and so the letters A B C D E F G H J K were used.

2. *Experiments with the Different Tasks.*

In the first experiment all four of the tasks were tried with the same subject. This subject, a woman, knew the nature of the experiment, but had received no preliminary training in it. The procedure was as follows: The subject worked about one hour on task one with no disturbance. The next day at the same hour on the same task with disturbance throughout the hour. In the same way the next two days were devoted to test two. The following two days were devoted to tests three and four, an afternoon and evening sitting being given on each day, the quiet period in the afternoons and the noisy ones in the evenings. The noises used in these experiments were the combination of nine noises described in Chapter II. Changes were made at rapid though uneven intervals from one to the other all through the disturbance hour. The results may be seen in Table I.

In calculating the results of this and all the following time records, the time was measured for every ten reactions, hence each time figure is for ten reactions. The probable errors given are the median deviations of these measures from the averages, divided by the square root of the number of cases. Since in different places a different number of measures are averaged, this method was used throughout in order to give comparable measures of reliability.

This table reveals very little practise effect in any of the tasks. In the first task the last group is actually slower than the first. We cannot explain just why this is the case but from the nature of the test it is probable that after the first several hundred reactions it became monotonous and the subject settled down to a slower, even movement. At first there was slight improvement, then after the six hundredth group there was a decline to 13.5 seconds. This speed was maintained through the remainder of the first period and likewise through the second in spite of the disturbance. It might seem at first glance that the fact that the second period shows slower time through the middle indicates the effect of the

TABLE I

Time Records of One Subject with Four Different Tasks

Task I

	Quiet		Noisy	
Reactions	Av.	P.E.	Av.	P.E.
1–100	12.3	*0.6*	12.8	*0.2*
101–200	13.6	*0.3*	13.0	*0.3*
201–300	11.9	*0.3*	13.5	*0.3*
301–400	11.0	*0.1*	13.2	*0.2*
401–500	11.7	*0.2*	13.8	*0.2*
501–600	11.9	*0.2*	13.4	*0.2*
601–700	13.5	*0.2*	13.1	*0.2*
701–800	13.7	*0.2*	13.4	*0.3*
801–900	14.2	*0.4*	13.6	*0.2*
901–1000	13.5	*0.2*	14.4	*0.2*

Task II

	Quiet		Noisy	
Reactions	Av.	P.E.	Av.	P.E.
1–100	33.3	*0.9*	22.9	*0.3*
101–200	30.2	*0.6*	24.3	*0.3*
201–300	28.2	*0.6*	25.6	*0.3*
301–400	27.5	*0.7*	24.6	*0.3*
401–500	36.7	*0.6*	24.2	*0.3*
501–600	24.2	*0.2*	25.7	*0.4*
601–700	22.2	*0.3*	24.7	*0.2*
701–800	24.0	*0.3*	24.4	*0.3*
801–900	36.7	*0.5*	24.5	*0.6*
901–1000	24.7	*0.5*	23.5	*0.3*

Task III

	Quiet		Noisy	
Reactions	Av.	P.E.	Av.	P.E.
1–100	47.4	*0.6*	40.2	*1.2*
101–200	45.5	*0.9*	41.0	*0.6*
201–300	43.6	*0.6*	41.4	*0.5*
301–400	42.8	*0.7*	41.0	*0.7*
401–500	41.6	*0.6*	42.7	*0.9*

Task IV

	Quiet		Noisy	
Reactions	Av.	P.E.	Av.	P.E.
1–100	59.7	*0.9*	44.3	*1.1*
101–200	56.6	*1.5*	45.4	*0.8*
201–300	50.0	*0.9*	46.2	*0.9*
301–400	52.2	*1.5*	45.6	*1.3*
401–500			46.6	*0.5*
501–600			50.1	*1.1*
601–650			59.7	*2.3*

The column of averages gives the average of the hundred reactions indicated in the first column. The probable errors are the median deviations of each group of ten in the hundred divided by the square root of ten. As the times were figured in groups of ten each figure represents the seconds required for ten complete reactions.

noises, but when the two periods are taken together it hardly seems the case. The first period showed the subject that the test period was rather long and so in the beginning of the second period she settled down to the steady pace acquired in the first period. For this reason it seemed that this task was not as suitable as some of the others for our purpose. We wanted a test that would require alertness on the part of the subject.

The second task likewise shows little practice effect although more than the first. After the first four hundred reactions the score is practically on a level for the rest of the hour. In the disturbance hour the subject begins at the same rate (except for a slight initial spurt) that had been attained the day before and carries this through the hour in spite of the noises.

Task three shows little difference from task two except that the absolute time is longer. We scarcely have a fair representation of the value of task four, as the subject was limited for time the first period. It seems on the whole to show a slowing up during the disturbance period, although the first part of that period shows a better record than that attained in the previous quiet period.

We reached two conclusions as a result of these tests. First, to carry on the work with all four tasks seemed of little value, since apart from the absolute differences in time three of the tasks gave the same results. As to which to adopt we had not enough data to decide. As we have said, the first seemed to require too little attention and so we decided not to use it. The next experiment will show another comparison of the second and fourth tests: As the second and third were so nearly alike in results to have used both of them would have been useless.

In the second place these results showed us that the procedure followed thus far was not likely to bring definite results. The rest period between the two sittings made the disturbance period incomparable to a large extent with the practise period. Any change in time between the two, unless very large and in a definite direction for a large number of subjects, might be due to other factors than the noise disturbance. This method was used at first because it was expected that a longer practise period would be needed. Since this work showed however that after about four hundred reactions there was very little improvement, it was decided to have quiet and noisy periods all at one sitting.

In the next experiment a different subject was used in tasks two and four, in order to try out the method of having the disturbance and quiet periods alternate in the same sitting, and also to get a comparison between the two tasks. As in the preceding, the combination of nine noises were used for the disturbances. The records are given in Table II.

In task two there is a slight improvement as far as seven hundred reactions. From there on there is practically no improvement. The record shows little effect of the noises. There is a slight decrease in speed at the beginning of each noise period followed by an acceleration, until the noises ceased. With task four the practise limit is about reached in the fourth hundred. Here we notice again the acceleration while the noises are going on and a slowing of speed after the noises cease.

This test shows clearly that the procedure here used is better than the preceding. If there is any effect of the noise on the time it will show when placed in sharp contrast with immediately preceding and folllowing quiet periods. While there seems little difference in the results of the two tasks, task four shows a little more flexibility than does two. Besides the arrangement in task four made it impossible to memorize any of the letter combinations; the complication of two sets of letters, one set of figures, and three colors

TABLE II

Time Records of One Subject with Tasks Two and Four

	Task II			*Task IV*	
	Quiet			Quiet	
Reactions	Av.	P.E.	Reactions	Av.	P.E.
1–100	18.2	*0.3*	1–100	32.9	*0.4*
101–200	17.6	*0.2*	101–200	33.3	*0.4*
201–300	16.4	*0.1*	201–300	30.9	*0.3*
301–400	15.9	*0.3*	301–400	29.5	*0.3*
401–500	15.6	*0.1*	401–500	26.8	*0.5*
501–600	15.3	*0.3*			
601–700	15.0	*0.1*		Noise	
701–800	14.6	*0.2*			
801–900	15.2	*0.1*	501–600	26.5	*0.2*
901–1000	14.9	*0.1*	601–700	25.7	*0.3*
			701–800	25.5	*0.3*
	Noise		801–860	25.6	*0.6*
1001–1100	15.4	*0.3*			
1101–1200	14.5	*0.2*			
1201–1300	14.3	*0.2*		Quiet	
1301–1400	14.5	*0.1*	861–900	26.2	*0.5*
1401–1500	14.5	*0.2*	901–950	28.1	*0.4*
	Quiet			Noise	
1501–1600	14.7	*0.2*	951–1010	26.6	*0.6*
1601–1700	14.4	*0.1*	1011–1060	24.9	*0.4*
	Noise			Quiet	
1701–1800	14.3	*0.2*	1061–1110	27.1	*0.4*
1801–1900	14.3	*0.2*	1111–1160	28.2	*0.4*
	Quiet				
1901–2000	14.4	*0.2*			

The first column gives the group of reactions of which the second column is the average. Each number represents the time for ten reactions. The P.E. is the median deviation divided by the square root of the number of cases.

keeps the subject on the alert, leaving no time for memorizing. It might be possible to fall into a rhythmic movement in reacting in task two, but not with task four. Hence we decided throughout the remainder of the experimenting to use task four. It had been planned to use all four tasks through the whole experiment, but we obtained little promise of finding any different effect with the different tasks we had chosen. They probably involved too nearly the same procedure to be affected differently.

II. *Experiments with Alternating Periods of Quiet and Noise*

In these experiments eight subjects were used, each subject for one sitting. Those marked A, B, C, and D in the table did not know that noises were to be introduced, while E, F, G, and H did.

D and H were women, all the rest were men subjects. B, C, D, E, F, and G were psychology students, B an undergraduate, the rest graduate students. A and G were not students. They worked about the university and had no experience in experimental psychology. H was the same subject who served in the work reported in Table I.

The procedure consisted in assigning to the subject the task described above as task four and introducing noises after he had worked for about half an hour in quiet. The noise period lasted about ten minutes and was followed by a quiet period. In some cases there were second noise periods given and in a few cases where time permitted the subject was given more than two noise periods.

The records for these experiments were calculated as before in groups of ten reactions. It was found that in every case there was little improvement in the first quiet period after the first half. In order therefore to put the results into comparable form each period, quiet and noisy, was divided into two equal parts, and the averages and probable errors calculated for each of these halves. They are given in Table III. A prolonged record was taken from subject H, and it is continued below the others. The figures below the times are the probable errors.

TABLE III

Speed Records in Alternating Quiet and Noisy Conditions

	Quiet		*Noisy*		*Quiet*		*Noisy*		*Quiet*	
A	61.8	62.9	61.6	57.8	63.2	58.5				
	1.8	*2.3*	*1.3*	*1.6*	*0.4*	*0.9*				
B	49.9	46.4	48.9	42.2	46.3	64.7				
	1.4	*0.6*	*0.5*	*0.6*	*4.2*	*3.9*				
C	47.7	43.4	50.0	45.5	45.5	40.5	44.5	40.5	38.5	42.3
	0.7	*0.7*	*0.3*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.2*	*0.1*
D	43.3	38.0	46.6	37.6	37.7	40.8	38.3	34.5	44.0	33.8
	0.6	*0.5*	*4.3*	*1.6*	*1.0*	*1.3*	*1.9*	*0.9*	*3.2*	*1.0*
E	32.0	28.2	26.5	25.6	26.2	28.1	26.6	24.9	27.1	28.2
	0.3	*0.3*	*0.3*	*0.3*	*0.5*	*0.4*	*0.6*	*0.4*	*0.4*	*0.4*
F	48.5	41.0	41.1	40.2	37.6	41.1				
	0.9	*0.8*	*1.8*	*1.2*	*1.7*	*2.0*				
G	45.7	40.4	39.0	35.8	35.5	38.3	36.3	34.7	38.5	37.0
	0.6	*0.5*	*0.5*	*0.2*	*0.3*	*1.3*	*0.7*	*1.1*	*0.9*	*1.4*
H	55.2	52.2	63.4	53.2	57.0	42.0	65.0	45.4	49.4	50.4
	0.4	*0.4*	*0.5*	*2.5*	*0.4*	*0.2*	*0.4*	*0.5*	*0.4*	*0.4*
H(continued)							53.0	48.0	50.0	40.4
							0.5	*0.4*	*0.5*	*0.4*

In five cases out of eight the first half of the first noise period shows a retardation in speed. Six out of the eight make better time in the second half of the first noise period than in the second half of the first quiet period. After the removal of the noise five show a slower reaction, one the same and two faster. A comparison of the second half of the second quiet period with the second half of the first noise period shows that with quiet six subjects make slower reactions than with the noises, while two make faster. In the beginning of the second noise period two make slower, three faster time than in the preceding quiet, while in the second half of this noise period the same three continue faster than in the preceding quiet. The last quiet period shows four subjects slower and one faster in both the first and second halves. The extension of H's record shows the same essential features with the exception that in the last score the best record is made.

In general, according to these eight subjects, the first introduction of the noises causes a retardation in time followed by an acceleration. The removal of the noise is likewise followed by a retardation which however is not succeeded by an acceleration as was the case in the noise period. The initial part of the second noise period does not show as much retardation as the first, nor is the retardation in the last quiet period as strong as that of the middle quiet period. We may state the facts briefly thus: Noise causes an initial slowing in speed followed by an increase, while the removal of the noises causes a retardation followed by normal.

In order to show more clearly the initial effect of the noise we have in Table IV presented the records for each of the eight subjects for forty reactions just before the noises were introduced and forty just after, in groups of ten reactions. The first part of the table

TABLE IV

INITIAL EFFECT OF NOISE

First Introduction

Subjects	Before Noise				During Noise			
A	58	62	76	66	65	61.5	71.5	62
B	43.5	44.5	45.5	44.5	57	58	44	44.5
C	43	36	40	48	53	46	47	44
D	37	35	40	38	56	45	39	34
E	29	26	25	27	31	26	26	26
F	38	40	36	36	55	43	40	33
G	37	36	41	46	48	39	40	39
H	52	52	55	50	64	62	51	53

Second Introduction

C	45	41	39	41.5	45	44	41	40
D	36	46	37	44	45	34	36	37
E	28	27	28	30	30	25	26	28
G	39	41	35	36	36	38	35	32
H	62	52	40	44	64	42	48	44

represents the work at the beginning of the first noise period, and the second division the introduction of the second noise period.

In this detailed presentation it will be seen that seven out of the eight react more slowly in the first score after the first introduction of the noises, four out of eight more slowly in the second score, four out of eight in the third, while only one out of the eight reacts more slowly in the fourth score after the noises were presented. This shows how rapidly the first slowing effect of the noises is overcome. At the second introduction of the noises three make slower and two the same time on the first score, two slower and three faster the second score, one slower and four faster the third score, while four react faster and one the same in the fourth score. Here we see less of the initial shock than at the first introduction.

III. *Noise and Accuracy*

In scoring any test where there are a large number of errors, it is always a problem to know how to penalize, but in this experiment the errors are too few to be significant. The records shown in Table III comprise in all 5,155 reactions. In all this number there were only 172 errors, a percentage of 3.34. In Table V we give the percentage of errors for each subject in both quiet and noisy periods.

TABLE V

PERCENTAGE OF ERRORS IN QUIET AND NOISY PERIODS

Subject	Quiet	Noisy	Quiet minus Practice
A	2.69	1.17	2.22
B	3.87	3.97	3.80
C	1.11	1.66	0.00
D	4.85	7.50	6.13
E	5.40	1.70	6.52
F	5.00	1.00	4.28
G	1.70	2.19	1.71
H	3.70	4.62	3.53

In this table the figures under the caption "quiet" represent the percentage of errors made during the entire experiment when there were no noises. Those under "noisy" the percentage of errors made during the disturbance periods. The last column shows the percentages of errors in the quiet periods minus the practise portion of each subject's work. The practise portion deducted was obtained by making a graph of each subject's record and noting approximately where the curve struck a level. Eliminating the portion of the work preceding this point leaves the period in which the conditions were most favorable for accurate work in direct comparison with the noise period; which comparison nevertheless reveals no ill effect of the noises. In five cases this last column shows a slightly lower percentage of errors than the first, which means that a few more errors were made during the practise section than after the work was learned; but this difference is far from reliable.

The small number of errors also makes the differences decidedly equivocal, since two errors more or less on one side would throw the difference in the opposite direction. The nature of the errors likewise shows that they are not a serious factor. With the apparatus we used the least touch of a key made a record; consequently if the subject struck the edge of the key next to the one he meant to press, both keys recorded. The majority of the errors in the scores shown were of this nature. For these reasons we can conclude that the error records in this experiment are not significant one way or the other.

IV. *Conclusions Derived from this Chapter*

The results obtained from the experiments reported in this chapter show that:

1. When the disturbing noises were first introduced they caused a retardation in the speed of the work.
2. This slow period was followed by an acceleration, the subjects exceeding the speed they had made before the introduction of the disturbing noises.
3. After the removal of the disturbances the subjects again did slower work.
4. A similar retardation at the introduction of the disturbance followed by an acceleration, and a retardation after the removal of the noise is seen in other disturbance periods than the first.
5. The records of errors do not show any inferior grade of work during the disturbance. They are too few to be of any significance.

The question now arises: How shall we interpret these results? At first thought it may seem to follow that a noisy condition is more favorable than a quiet one. If six out of eight make better time during noise than before the noises were introduced, and if six out of eight make slower time after the noises stop, might it not follow that noises have a dynamogenic effect, spurring the subject to increased activity? This might be a legitimate conclusion were it not for the initial retardation at the beginning of the noise periods. If the influence were one of simple dynamogenesis, it does not seem plausible that the first effect should be one of interference. If a motor is going at a certain speed and more current is turned on it does not first stop or slow down and then take on speed and exceed its former motion, unless the direction of the increased current is reversed.

It is therefore not a legitimate interpretation of the data to ignore the slowing effect or pass over it lightly and say that in general the effect of noise is a stimulation; just as it would not be a proper treatment of the data to average the whole period together and conclude that the noise had no effect.

After giving each feature of the results due weight we do not conclude that a noisy condition is just as conducive to good work as a quiet one. Our work thus far has simply served to show that noises have *some* effect upon work, and that the effect is a complex one. In the following chapters we shall report some work in which we have endeavored to analyze this complex.

CHAPTER IV

REACTION TO NOISE AS SHOWN BY BREATHING

A SURVEY[1] of the experimental work that has been done in an attempt to discover the relation, if any, between breathing and cerebral processes would tend to make one wary of a problem requiring so great an expenditure of time and patience, and so devoid of anything definite in the way of results. While it may seem almost self-evident that attention and the different emotions have some effect upon breathing, when subjected to experimental control, results of the most diverse sort have been obtained. Most of the work that has been done—the work in which there has been so little agreement—has been concerned with the rate of breathing. Recently several investigations have been reported which claim success along another line, namely, the manner of breathing regardless of the rate. Stevens,[2] while in his review of the literature finding only contradiction in reference to changes in the *rate* of breathing, concludes from his experiment that there is a constant relation between attention and *depth* of respiration.

Still more recently Benussi[3] declares that he has found an invariable relation between the ratio of the length of inspirations and expirations, and the truthfulness or falseness of a subject's replies to questions. His method was to record about six respirations, have the subject answer questions either truthfully or falsely, and then record six more respirations. He then measured the time taken for each inspiration and each expiration and found the ratio between them. He found that the relation between the ratio before and after truth telling was always different from that before and after lying.

While it must be shown by future work whether the condition he finds is peculiar to lying or not, the method of treating the breathing seems a promising one. It may be that a quantitative study of the manner of breathing will in the future be productive of more fruitful results than the study of breathing rates has been. At any rate we were curious to see what effect such an experiment as the present one would have on the breathing of the subject, and decided to use a method somewhat akin to Benussi's in treating the data.

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[1] For such a survey see: Stevens, H. C., "A Plethysmographic Study of Attention," *Amer. Jour. of Psychol.*, 1905, *16*, 409–483.

[2] *Ibid.*

[3] Benussi, V., "Die Atmungssymptome der Lüge," *Archiv f. d. gesamte Psychol.*, 1914, *31*, 244–273.

Two subjects were first used, one (I) knew what to expect in the way of noises and one (*J*) knew nothing of the nature of the experiment. The same procedure was followed as in the previous experiments, with the exception that a graphic record was taken of the breathing of the subject through the entire experiment. The disturbances were the same series of noises. The time for each inspiration and each expiration was then measured and the ratio found between them, dividing the expiration by the inspiration. The results of these two subjects with the probable errors are given in Table VI.

TABLE VI

BREATHING RATIOS OF TWO SUBJECTS

Subject	Before	Quiet			Noise		Quiet		Noise		Quiet		
I	1.89	2.42	3.17	1.95	2.05	02.00	1.77	1.78	1.98	2.13	1.49	1.51	Ave.
	0.04	*0.16*	*0.16*	*0.10*	*0.09*	*0.06*	*0.06*	*0.04*	*0.10*	*0.05*	*0.03*	*0.04*	P.E.
J	1.41	3.50	6.13	5.90	7.49	10.06	5.38	4.47	13.83	10.62	6.03	5.47	Ave.
	0.15	*0.15*	*0.23*	*0.38*	*1.04*	*1.76*	*1.18*	*0.52*	*1.18*	*1.00*	*1.54*	*0.72*	P.E.

In the case of subject I, the ratio before work was 1.89. As soon as the work was begun it rose to 2.42, after which it kept increasing until in the middle of the first quiet period it reached 3.17. It then dropped to about normal. As soon as the noises were introduced it rose again, and dropped once more in the following quiet. The same thing occurred at the second introduction of the noises. With subject J the difference was much more striking, the ratio being radically different as soon as the subject began to work from what it was before he began, and being also changed greatly by the introduction of noises. The explanation of this change in breathing did not become apparent until we tried other subjects. The next subject (K) began to speak aloud as soon as the noises began and continued to do so all through the disturbance period, his ratio changing the same as the other subjects. This gave the clue as to the change in ratio and arrangements were then made to watch the subjects, they of course not knowing they could be seen. The next subject, L, did not speak at all and his ratio shows little difference. M about the middle of the first quiet period moved his lips as he did the work, and when the noises came he first closed them for some time and then began to speak the letters aloud. In Fig. 4 are seen some typical curves, showing more or less change due to articulation. It can be seen that the type of curve changes, the inspiration becoming short, while the expiration be-

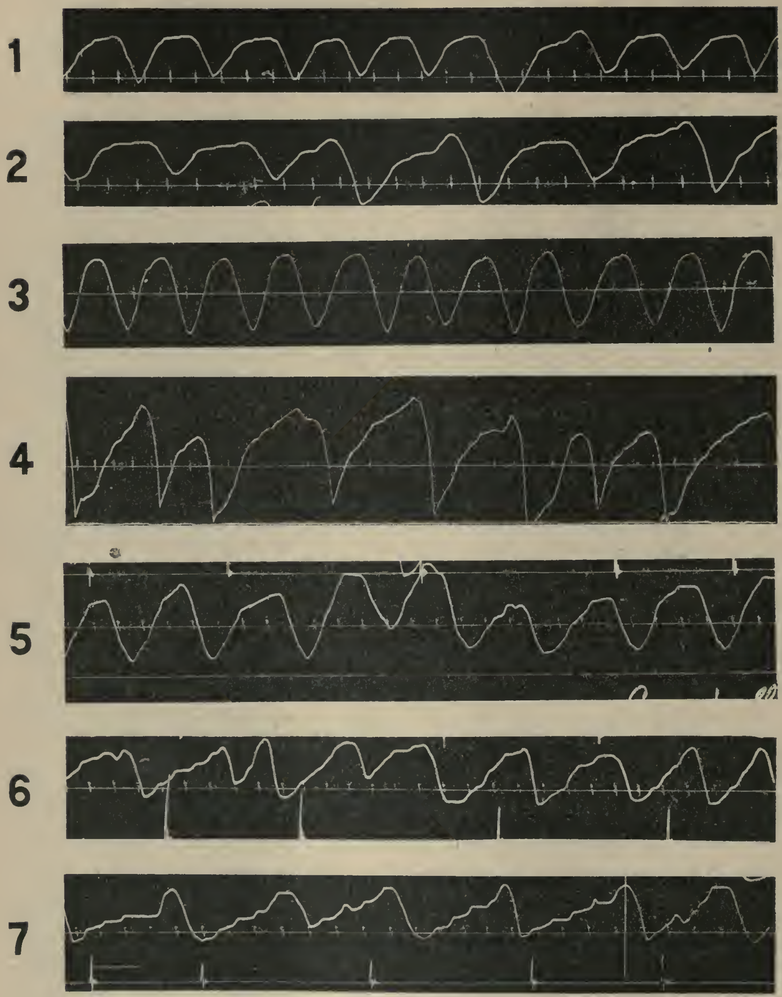

FIG. 4. Samples of breathing curves showing the changes caused by articulation. The curves read from left to right, and inspiration is recorded by a descent of the line, expiration by an ascent. The time line records intervals of a second.

1. Breathing curve of subject N while working in quiet.
2. Breathing curve of subject N while working in noise.
3. Breathing curve of subject T while working in quiet.
4. Breathing curve of subject T while working in noise.
5. Breathing curve of subject Br before he began to work.
6. Breathing curve of subject Br while working in quiet.
7. Breathing curve of subject Br while working in noise.

All of these subjects articulated during the noisy periods and subject Br during the quiet period as well. A comparison of 7 with 6 shows the increase in articulation of a subject who made vocimotor movements throughout the work.

The lines at the bottom of 6 and 7 are the records of the key pressure apparatus.

comes much lengthened. From these as well as later experiments where the subjects were watched it is certain that the extreme changes in ratio were due to the subject moving to a greater or less degree the organs of articulation as an aid in his reactions.

This throws important light on the nature of a subject's response to a noisy situation. It will be remembered that the task to be performed consisted in looking at the exposure opening where one of ten letters from the latter end of the alphabet was exposed on a colored background. The subject then had to look below the opening at a code and translate the letter to one of ten letters from the beginning of the alphabet. Then he had to look up above the exposure opening to one of three codes whose color corresponded to the one at the opening and then translate the letter to one of ten numbers, after which he pressed the corresponding key. Each pressure of the key brought a new letter and color to view and the subject repeated the process. Some subjects as soon as they began work articulated noticeably and continued to do so through the entire experiment, emphasizing the movements during the disturbances. Some did not do so noticeably until the disturbances came. The positive evidence that the more radical changes in the breathing ratio corresponded to the more extensive articulation and the weaker ones to lesser movements of the lips points to a relation between still smaller changes in ratio and weaker involuntary movements of the speech organs. If this can be shown to be the case by further investigations it may throw light on the work of Benussi and other work concerned with breathing and mental processes.

In order to see to what extent the subjects called in this aid to overcome the disturbance of the noises, ten different subjects were used for one sitting each. Only one of these subjects (*Q*) knew the nature of the problem. The same group of nine noises were used as disturbances. The procedure consisted in allowing each subject to make 400 reactions in quiet, the noises then being introduced and kept constantly sounding (changing from one to the other irregularly) for 200 reactions. The sitting closed with 200 reactions in quiet, making 800 reactions for each subject. Time and accuracy records were taken as well as continuous breathing records. The breathing ratios for these ten subjects are given in Table VII.

The averages given are for each hundred reactions with the exception that the first hundred reactions of the disturbance period are given in two groups of fifty each. Under each ratio is the probable error for that group.[4]

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[4] In order to economize time a change was made in the method of tabulating. Instead of measuring each inspiration and expiration separately, each group to be treated was divided into four approximately equal sections. The total time

TABLE VII

BREATHING RATIOS OF TEN SUBJECTS

		Quiet				Noise			Quiet	
	Before	1–100	101–200	301–300	301–400	401–450	451–500	501–600	601–700	701–800
K	1.84	2.04	2.22	3.04	3.13	5.14	4.42	4.67	3.56	3.08
		0.15	*0.13*	*0.40*	*0.13*	*0.02*	*0.26*	*0.46*	*0.26*	*0.25*
L	1.56	1.59	1.82	1.87	2.14	1.36	1.41	1.66	1.97	1.87
		0.09	*0.04*	*0.05*	*0.03*	*0.09*	*0.02*	*0.16*	*0.01*	*0.10*
M	1.43	1.56	1.95	3.15	2.88	1.44	4.92	4.33	2.48	2.08
		0.04	*0.18*	*0.37*	*0.04*	*0.07*	*0.92*	*0.57*	*0.10*	*0.09*
N	2.21	2.15	2.57	2.41	2.09	2.39	2.75	2.78	2.29	2.20
		0.13	*0.02*	*0.02*	*0.09*	*0.07*	*0.07*	*0.10*	*0.05*	*0.01*
O	1.14	1.55	1.52	1.50	1.51	1.62	1.85	1.68	1.52	1.71
		0.07	*0.04*	*0.10*	*0.15*	*0.02*	*0.09*	*0.05*	*0.03*	*0.07*
P	1.84	1.33	1.25	1.24	1.25	1.49	1.64	1.13	1.24	1.27
		0.05	*0.03*	*0.09*	*0.05*	*0.06*	*0.07*	*0.05*	*0.05*	*0.06*
Q	1.26	1.97	2.36	2.58	2.55	2.26	2.94	3.40	2.36	2.31
		0.11	*0.14*	*0.11*	*0.25*	*0.68*	*0.45*	*0.24*	*0.13*	*0.22*
R	1.32	1.72	1.86	2.28	2.24	1.35	1.48	1.70	1.97	1.40
		0.04	*0.05*	*0.06*	*0.09*	*0.04*	*0.07*	*0.05*	*0.15*	*0.08*
S	1.19	1.53	1.86	1.62	1.57	1.26	1.41	1.49	1.42	1.35
		0.07	*0.03*	*0.04*	*0.16*	*0.04*	*0.03*	*0.04*	*0.09*	*0.09*
T	1.45	1.41	2.25	1.96	1.62	1.35	2.46	3.42	1.70	2.14
		0.07	*0.09*	*0.08*	*0.05*	*0.13*	*0.31*	*0.18*	*0.07*	*0.07*
Ave.	1.53	1.68	1.97	2.17	2.10	1.97	2.53	2.63	2.05	1.94
Av. of P.E.		*0.08*	*0.08*	*0.13*	*0.10*	*0.12*	*0.22*	*0.19*	*0.09*	*0.10*

Nine of the ten subjects show a larger ratio during work than in the period before work. Seven of the ten show a larger ratio

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for inspirations and expirations was found for each section and the ratio calculated from this. The probable error for each group is of four sections. This method, unless the distribution is much skewed, will not change the results. Several groups, selected at random from different subjects, were calculated in both ways in order to see if the difference was significant.

Measuring each reaction separately.............	Av.	1.89	1.55	1.96	3.03
	P.E.	*0.04*	*0.02*	*0.09*	*0.28*
Measuring by groups of four..................	Av.	1.90	1.53	1.94	2.99
	P.E.	*0.07*	*0.04*	*0.18*	*0.37*

The figures show that the averages are changed very little. The probable errors in the case of the more tedious method are smaller. The reason for this is that the groups of consecutive respirations differ more than would be expected from random samplings, while the cases within the same group differ less.

during the disturbance than during quiet. This shows quite a general tendency to articulate during the work as well as a tendency to use this as a help to overcome the disturbing noises. All of those who evidently used articulation as a help during the noises show a decrease in ratio after the noises stop. The averages of all subjects for each period show a tendency of the ratio to rise to a fairly high point during the quiet period, reaching its maximum at the 201–300 group and then to fall somewhat. At the first introduction of the noises the ratio is still lower, after which it rises to a higher point than it has yet reached. After the noises stop it again falls. It is evident that when the noises begin the subjects are somewhat confused and work ahead blindly and make slower time than they did during the quiet. After the first fifty reactions or so they begin to realize that they are in a situation not conducive to good or rapid work and then strike about for a means to overcome it. Those who discover the help of articulation overcome the slowing effect of the noises and make better time than they did during the quiet. (See Table IX.) That this effect in the averages of ratios is not produced by a few cases is shown in Table VIII where

TABLE VIII

Relative Ranking of Ratio Scores for each Subject

	Quiet				Noise			Quiet	
Subject	1–100	101–200	201–300	301–400	401–450	451–500	501–600	601–700	701–800
K	1	2	3	5	9	7	8	6	4
L	3	5	6.5	9	1	2	4	8	6.5
M	2	3	7	6	1	9	8	5	4
N	2	7	6	1	5	8	9	4	3
O	5	3.5	1	2	6	9	7	3.5	8
P	7	4.5	2.5	4.5	8	9	1	2.5	6
Q	1	5	7	6	2	8	9	4	3
R	5	6	9	8	1	3	4	7	2
S	6	9	8	7	1	3	5	4	2
T	2	7	5	3	1	8	9	4	6
Av.	3.4	5.2	5.5	5.15	3.5	6.6	6.4	4.8	4.45
A.D.	*1.8*	*1.5*	*2.5*	*2.3*	*2.9*	*2.4*	*2.2*	*1.3*	*1.6*

for each subject the different periods are given a ranking from 1 to 9 (omitting the period before work) from the lowest ratio to the highest. The periods were arranged according to their relative positions regardless of amount of difference, thus eliminating all chances of one or two excessive scores controlling the averages.

Treating the scores in this manner gives the same result. The averages of orders gives in the first group the position 3.4, the next two 5.2 and 5.5 after which at the close of the quiet period it drops to position 5.15. At the introduction of the noises the average position is as low as 3.5. It then rises to 6.6 and 6.4. After the noises cease it drops again to 4.8 and 4.45.

Thus far we have considered the general tendency of the group. Let us look now more closely at those cases that do not follow this tendency. Their status can be seen by comparing the breathing ratios of Table VII with the time scores given in Table IX. Here it will be seen that there are some exceptions to the rule we previously found that subjects do as good or better work during noise than in quiet. The most striking exceptions are the subjects R, and S. These, who do not make better time during the noises, are the ones who do not show a lengthening in breathing ratios. Besides P, N, and O show longer times during at least part of the noise period, and likewise show little increase in breathing ratio. It is certainly evident that those subjects who excel in speed during the disturbances call in the aid of articulation as a means of overcoming the disturbances. The only clear exception is L, who made shorter time and who also shows no lengthening in breathing ratio. If the aid of articulation was the only factor by means of which the subject could modify his time score, we might expect a correlation between the time and breathing ratio scores; but, as will appear later, other factors are operative which cannot be expressed by correlations.

The breathing rates were also calculated for each subject through the entire periods and are given in Table X. The figure given is the average time per respiration. The figure beneath is the probable error for the group. The relative ranking is also given for each subject. While with some subjects a lengthening of the ratio was accompanied by a slower rate, with other subjects the action was just the opposite; and while the time averages as well as the relative position averages show somewhat the same effect, we could find no definite relation between the rate of breathing and articulation. A subject can change the length of ratio by articulation and at the same time either increase or decrease in rate. This shows that a statistical study of the manner of breathing gives information that would be made obscure and equivocal were the rates alone considered. Outside the fact that the breathing seems to be a little quicker at the beginning of work and at the beginning of the noise period, the breathing rate figures show little of anything definite. This quickening may, taken with the evidence from the other scores, be interpreted as an index of excitement at these two points in the experiment, but the lack of reliability of the rate scores taken alone is shown in the relative position scores. When there is little correspondence in ranking between the several individuals

TABLE IX

Time Scores of Ten Subjects

	Quiet				Noise			Quiet	
Subject	1-100	101-200	201-300	301-400	401-450	451-500	501-600	601-700	701-800
K	49.2	56.4	62.6	58.6	50.8	47.0	47.0	61.1	53.9
	1.4	*1.6*	*4.6*	*6.4*	*1.3*	*0.9*	*0.9*	*1.3*	*2.3*
L	46.2	42.0	38.6	38.3	42.6	37.0	36.1	39.7	40.6
	0.4	*0.6*	*0.5*	*0.7*	*2.2*	*0.9*	*0.9*	*0.8*	*6.3*
M	65.6	58.1	58.6	57.3	74.2	49.7	55.8	58.2	66.1
	0.8	*2.5*	*2.4*	*0.7*	*9.9*	*2.0*	*1.6*	*3.5*	*2.1*
N	51.7	47.7	44.8	46.0	53.6	38.3	46.4	41.5	45.0
	1.0	*1.3*	*1.6*	*0.6*	*3.4*	*1.4*	*2.0*	*1.4*	*1.7*
O	47.5	46.0	41.5	39.8	38.8	41.8	40.2	39.2	37.8
	1.0	*0.8*	*1.0*	*0.9*	*0.5*	*1.0*	*0.5*	*1.0*	*0.5*
P	45.0	40.2	36.2	36.1	48.0	42.0	38.1	35.9	35.2
	1.4	*1.1*	*0.6*	*0.7*	*2.7*	*2.7*	*2.2*	*0.5*	*0.6*
Q	49.0	44.8	41.5	40.1	47.8	36.4	34.9	36.2	33.7
	1.3	*1.0*	*1.1*	*1.4*	*1.4*	*1.2*	*1.3*	*0.8*	*2.4*
R	52.5	47.8	42.1	41.5	46.0	41.6	42.1	43.0	41.2
	1.1	*1.0*	*0.4*	*0.5*	*1.8*	*0.3*	*0.4*	*0.6*	*0.6*
S	45.6	42.0	35.9	35.7	39.4	37.6	36.3	37.5	35.4
	0.6	*1.1*	*0.6*	*0.7*	*2.0*	*1.6*	*0.5*	*0.5*	*0.8*
T	63.7	50.8	56.1	51.3	46.4	44.0	43.7	50.3	47.6
	1.1	*2.2*	*2.2*	*2.4*	*2.2*	*1.3*	*1.3*	*1.3*	*1.6*
Av.	51.6	47.6	45.8	44.5	48.8	41.5	42.1	44.3	43.6
Av. of P.E.s	*1.0*	*1.3*	*1.5*	*1.5*	*2.7*	*1.3*	*1.2*	*1.2*	*1.9*

Relative Ranking of Time Scores

K	3	6	9	7	4	1.5	1.5	8	5
L	9	7	4	3	8	2	1	5	6
M	7	4	6	3	9	1	2	5	8
N	8	7	3	5	9	1	6	2	4
O	9	8	6	4	2	7	5	3	1
P	8	6	4	3	9	7	5	2	1
Q	9	7	6	5	8	4	2	3	1
R	9	8	4.5	2	7	3	4.5	6	1
S	9	8	3	2	7	6	4	5	1
T	9	6	8	7	3	2	1	5	4
Av.	8.0	6.7	5.4	4.1	6.6	3.8	3.2	4.0	3.2
A.D.	*0.8*	*1.0*	*1.6*	*1.5*	*2.2*	*1.0*	*1.7*	*1.0*	*3.8*

of the experiment, their averages tend to bring them all together. The fact that the difference between the lowest and highest ranking is only 3.2 positions out of a possible 9 is indicative of a lack of correspondence between the individuals as to changes in breathing rate.

TABLE X

Breathing Rates of Ten Subjects

		Quiet				Noise			Quiet	
Subject	Before	1–100	101–200	201–300	301–400	401–450	451–500	501–600	601–700	701–800
K	5.09	3.44	4.03	4.00	3.84	4.12	4.07	3.84	4.19	3.95
		0.20	*0.15*	*0.12*	*0.07*	*0.01*	*0.15*	*0.16*	*0.12*	*0.24*
L	3.94	2.80	2.77	2.85	2.75	2.10	2.27	2.89	3.23	2.83
		0.08	*0.07*	*0.03*	*0.02*	*0.02*	*0.07*	*0.06*	*0.05*	*0.05*
M	2.92	2.37	2.50	3.70	3.56	2.50	4.87	5.33	3.64	3.76
		0.05	*0.27*	*0.08*	*0.13*	*0.18*	*1.04*	*0.14*	*0.06*	*0.05*
N	4.25	2.69	3.07	2.98	3.19	3.07	3.42	3.56	3.03	3.20
		0.15	*0.09*	*0.04*	*0.11*	*0.07*	*0.14*	*0.05*	*0.06*	*0.09*
O	3.60	3.20	3.47	3.52	3.38	2.20	2.84	2.67	3.33	3.07
		0.11	*0.24*	*0.21*	*0.16*	*0.14*	*0.07*	*0.06*	*0.03*	*0.15*
P	3.71	2.90	3.12	3.26	3.22	3.10	3.39	3.04	3.49	3.42
		0.06	*0.05*	*0.06*	*0.09*	*0.02*	*0.25*	*0.03*	*0.06*	*0.13*
Q	3.35	2.65	3.32	3.02	3.54	3.24	3.46	3.26	3.02	2.78
		0.18	*0.49*	*0.05*	*0.17*	*0.12*	*0.05*	*0.04*	*0.21*	*0.16*
R	3.06	2.98	2.78	2.99	2.86	3.00	2.93	2.76	3.18	2.94
		0.06	*0.06*	*0.08*	*0.12*	*0.04*	*0.06*	*0.05*	*0.06*	*0.05*
S	2.85	2.72	2.98	2.84	2.71	2.15	2.35	2.35	2.66	2.47
		0.09	*0.05*	*0.09*	*0.03*	*0.09*	*0.04*	*0.07*	*0.14*	*0.09*
T	2.63	2.62	3.76	3.51	2.88	2.58	3.70	4.63	3.10	3.24
		0.06	*0.13*	*0.10*	*0.02*	*0.20*	*0.30*	*0.10*	*0.11*	*0.04*
Av.	3.54	2.84	3.18	3.27	3.19	2.11	3.33	3.43	3.29	3.17
Av. of P.E.s		*0.10*	*0.16*	*0.09*	*0.09*	*0.09*	*0.22*	*0.08*	*0.09*	*0.11*

Relative Ranking of Rate Scores

K	1	6	5	2.5	8	7	2.5	9	4
L	5	4	7	3	1	2	8	9	6
M	1	2.5	6	4	2.5	8	9	5	7
N	1	4.5	2	6	4.5	8	9	3	7
O	5	8	9	7	1	3	2	6	4
P	1	4	6	5	3	7	2	9	8
Q	1	7	3.5	9	5	8	6	3.5	2
R	6	2	7	3	8	4	1	9	5
S	7	9	8	6	1	2.5	2.5	5	4
T	2	8	6	3	1	7	9	4	5
Av.	3.0	5.5	5.95	4.85	3.5	5.65	5.1	6.25	5.2
A.D.	*2.2*	*2.1*	*1.5*	*1.7*	*2.3*	*2.2*	*3.1*	*2.2*	*1.5*

SUMMARY OF CHAPTER

1. It was found that movements of the speech organs caused a change in the breathing. These changes corresponded in a general way to the extent of the movements; speaking aloud caused greater changes than whispering and simple movements of the lips lesser changes than whispering.

2. The ratio between the inspiration and expiration time expresses this change numerically.

3. The general tendency was for subjects to make movements of their speech organs as they performed the task.

4. There was likewise a general tendency to increase these movements as they worked in the midst of noises. This is shown by the increase in the breathing ratio.

5. Those subjects who called to their assistance this means of overcoming the effect of the noises increased in speed during the noises, and those who did not showed no such increase. There was only one exception to this.

6. This aid was not called forth at the very beginning of the noise period. It probably takes some time for the subject to awaken to the nature of the situation. The low breathing ratios at the beginning of the noise periods correspond closely to the slowing in time noted in the last chapter. When he realizes that he is being disturbed the subject begins to articulate, his breathing ratio increases and his time decreases.

CHAPTER V

Comparison of Quiet and Noisy Periods with Respect to Effort

At the same time that we were experimenting with the breathing, it was desired to get some test which would indicate whether the subject was working at a greater tension while the noises were going on than when it was quiet. Several devices were tried in an effort to get a record of the involuntary movements of the subject while at work. The first two devices tried were not satisfactory for this experiment. One was to have the subject hold a rubber bulb in his left hand, any changes in pressure on this bulb making a record on a kymograph. We found, as did Geissler,[1] that it was allowed to rest lightly in the hand and most of the time gave only a straight line for a record. We then devised a dynamometer that required a certain strain on the part of the subject or it would fly out of his grasp. This however served as a greater disturbance than the noises. The subject would stop work entirely in order to readjust his hold and seemed more interested in holding it properly than in reacting, which of course made the record useless for our purpose.

We then tried to get a test that could be obtained without the subject being aware of it. A good one seemed that of taking a record of the amount of pressure exerted on the keys in the reactions, as such a test would have to receive some response from the subject, for he was forced to press the keys in order to react. It had the advantage of being directly related to the work in hand; hence a change in response would certainly be indicative of a change in his manner of reacting in the main task, which would facilitate interpretation of the results. If it could be obtained without the knowledge of the subject it would have the additional advantage of being free from voluntary modification by him.

As was stated in Chapter II in the description of the device used to record the pressure exerted on the keys, the apparatus that we adopted met this last condition to an unlooked-for degree. None of the subjects knew that his record was being taken till the experiment was concluded. For this reason we regard the results from this test as highly reliable. We have seen from the results of the time scores that when a subject knows a certain test is being made he does his best to make that score good. If his time is being taken and noises are sounded, he does his best and tries to show that he is not affected by the noises. Now such a reaction may be all right when individuals or groups are to be compared, but when the effect of some condition is to be studied such a response is disastrous. It covers the effect of the condition, and the experimenter is forced to conclude that he finds no effect of such a condition on the process tested; when as a matter of fact it had an effect but was hidden by the change in the subject's response. Let us see then if the results obtained in the previous chapters will have to receive a different interpretation in the light of this test of which the subject was in total ignorance.

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[1] Geissler, L. R., "The Measurement of Attention," *Amer. Jour. of Psychol.*, 1909, *20*, 509.

Key pressure records were obtained from the last six subjects reported on in the last chapter, in connection with the breathing records. For these six subjects as well as all those that will be reported later we took simultaneous time, accuracy, breathing, and key pressure records. The keys were carefully tested, and a scale constructed with a unit of fifty grams to correspond to the movement of the recording stylus in response to that pressure. Each key pressure record was measured by this scale and the measures grouped into hundreds to correspond to the other records; with the exception that the first hundred reactions of the noise period were divided into two groups of fifty. The average pressure in grams for each group was found with its probable error and appears in Table XI.

The figures in the lower table represent the relative ranking of each group from the lowest pressure to the greatest for each subject. In every case the keys were pressed with greater force during the noisy period than during the quiet. The probable errors show that this difference is reliable in every case. As a rule the subjects tended to use greater force in pressing the keys at the beginning of the experiment than they did after they became accustomed to the work. When noises are introduced they press with as great or greater force than at the beginning of the experiment. It does not drop again to a low pressure until the noises stop, when it falls to a lower point than it had reached before the noises came.

The force with which the keys are struck varies greatly with different subjects, covering a range from 100 to 1120 grams; which is probably due to the difference in the manner of touching the keys. Some subjects give a slow pressure, and these subjects as a rule record a light pressure. Others give the keys a quick and comparatively hard blow, which of course would give the recording stylus a greater movement. In spite of the great variation in the manner of striking the keys, the change in pressure is in every case

TABLE XI

KEY PRESSURE RECORDS OF SIX SUBJECTS

	Quiet				Noise			Quiet	
Subject	1–100	101–200	201–300	301–400	401–450	451–500	501–600	601–700	701–800
O	671	418	411	406	525	465	439	347	346
	13	*6*	*12*	*6*	*11*	*9*	*6*	*6*	*5*
P	316	204	118	130	252	285	287	126	101
	8	*4*	*3*	*4*	*9*	*11*	*5*	*3*	*3*
Q	293	197	150	115	300	302	235	180	165
	14	*7*	*4*	*4*	*8*	*8*	*5*	*4*	*3*
R	976	872	905	935	1120	985	1008	798	798
	10	*12*	*12*	*11*	*17*	*14*	*12*	*8*	*11*
S	165	168	171	137	162	170	175	110	100
	3	*4*	*4*	*3*	*6*	*5*	*4*	5	*4*
T	208	156	123	109	269	325	281	190	144
	9	*3*	*5*	*6*	*8*	*9*	*5*	*5*	*4*
Av.	438	336	313	305	438	422	404	292	276
Av. of P.E.s	*9*	*6*	*7*	*6*	*10*	*9*	*6*	*5*	*5*

RELATIVE RANKING

O	9	5	4	3	8	7	6	2	1
P	9	5	2	4	6	7	8	3	1
Q	7	5	2	1	8	9	6	4	3
R	6	3	4	5	9	7	8	1.5	1.5
S	5	6	8	3	4	7	9	2	1
T	6	4	2	1	7	9	8	5	3
Av.	7.0	4.7	3.7	2.8	7.0	7.7	7.5	2.9	1.75
A.D.	*1.3*	*0.6*	*1.7*	*1.2*	*1.3*	*0.9*	*1.0*	*1.1*	*0.8*

significant. This measure gives every evidence of being indicative of the tension under which the subject works. We are not sure that this can be held to be true in comparing different subjects; for instance, we can not say for certain that R worked under a greater tension or strain than P. This might be the case, although it is more likely to be the peculiarity in the subject's manner of striking the keys, but in comparing different periods for the same subject, we believe difference in pressure does indicate the relative effort exerted. If a subject fell into the habit of giving the keys a quick hard blow and in normal conditions averaged 935 grams, and when a disturbance was introduced reached 1120 grams, this would certainly mean that the subject gave the keys a harder blow; and such an increase in force would be indicative of an increased nervous discharge into the reacting movement, which in turn would indicate that the subject was in a state of greater nervous tension than before the noises came.

When the subject first begins work he is in a comparatively high state of tension; he wants to make a high score and keys himself up to it. As he works for half an hour and becomes accustomed to the task, he tends to relax somewhat. When the noises come on he sees that he has an additional factor to cope with, strains himself to a greater degree to meet it, and, as we have seen in the last chapter, calls in some new factor to aid him, so that his score may not be affected by this new intruder, noise. Although he relaxes a little as the noises continue, he keeps himself in a comparative state of tension until the noises stop, when he relaxes and his pressure is weaker than at any time in the experiment.

In order to make vivid the fact that these different tests measure different things and are not simply a different check on the same think, the correlations between the different scores were calculated and are presented in Table XII. The correlations for each subject were kept separate, and are so given. The method used in calculating them was that of "Differences in Relative Positions or Ranks," the formulæ being

$$r = 2 \sin \left(\frac{\pi}{6} p \right)$$

and

$$p = 1 - \frac{\Sigma D^2}{\frac{n(n^2 - 1)}{6}};$$

in which r equals the Pearson coefficient of correlation; ΣD^2, the sum of the squares of the differences in rank; and n the number of cases.

TABLE XII

Correlation of Scores from Various Tests

Subject	Time and Breathing Ratio r	Time and Key Pressure r	Breathing Ratio and Breathing Rate r	Breathing Ratio and Key Pressure r
O	−.157	.58	−.804	.28
P	.466	.794	−.042	.28
Q	−.477	.292	.647	−.09
R	.052	.209	.01	−.43
S	.115	.261	.89	.42
T	−.547	−.677	.96	.292
Av.	−.091	.243	.277	.125

With two subjects the correlation between the breathing rate and breathing ratio is high, but with the others it varies as far as a high negative correlation. Between the time and breathing ratio and the time and key pressure tests there is practically no correlation. We can see then that each of these tests measures a different thing.

To have measured the subject's time and drawn our conclusions from it alone (the accuracy records were insignificant throughout) would have been to have told only a small part of the story. With the two additional tests we can see with what cost the subject makes better time during the latter part of the noise period. With some subjects this is accomplished with the aid of articulation, while all subjects are at a greater strain.

Although the results of these experiments are definite, it may be felt that the subjects were too few to make them conclusive. We therefore carried the experiment much further and give in the next chapter a report of a much more elaborate series. Here also the conditions are somewhat changed, so that any incidental factor which might have influenced the results heretofore is eliminated. The evidence for our conclusions will become doubly strong when we have presented these experiments.

If we look back at the breathing ratio records (Table VII) of the subjects whose key pressure records are reported in Table XI, we see that subjects R and S are exceptions to the general tendency to articulate during the noises. The time records (Table IX) of these two subjects show very little difference during the noises from that of the normal conditions, except for the initial slowing. If we had simply the time and breathing records we should have to conclude that these two subjects were not hindered by the noises. In the light of the key pressure tests, however, we can say that while they did as rapid work and show no evidence of speaking to help themselves against the noises they worked at a greater tension.

These results show that the test of which the subject was totally ignorant gave the best results. This indicates, we believe, what should be the nature of tests to determine the influence of conditions upon human activity; for it is impossible to vary conditions to any marked degree without the subject becoming conscious of it, and his recognition of an added difficulty leads him to extra exertion to overcome it.

It may be thought that if this is the case the introspective evidence of a trained subject would reveal it. To discover whether we could obtain the information in this way every subject was asked if he put forth greater effort to combat the noises, whether he found it more difficult to work during the time when the noises were in progress. Only two subjects (whose records will be given later) confessed that they were bothered by the noises. These two subjects made slower records all through the noise periods. All confessed that it took greater effort at the beginning of the noise period. From these statements we believe that the subject's judgment of the difficulty of a task and the amount of effort he is exerting is simply a judgment of the rapidity with which he works. The fact of the case is, that after the first period he was able by strain and speaking to go as fast or faster than before the noises, and because he worked as rapidly he did not think it required extra effort.

Nor do we believe from our results that a judgment of the pleasantness or unpleasantness of the task is a report based on the effort put forth. The two subjects referred to above who did slower work and confessed that they had to work harder, were the only ones who said that the test was unpleasant. While we made no attempt to get a scale of pleasantness we asked all the subjects how they liked it, or some similar question. They would invariably laugh and give answers such as these; "I enjoyed it," "That's a good one," "You put one over on me that time," "Fine," "Say, that's all right." It was regarded as a joke because they had no idea that noises were to be given. Other factors enter into reports of pleasantness or unpleasantness than the amount of effort required.

Theoretically it might be possible to devise a test of such intense difficulty that the subject would have to exert himself to the utmost each moment. A disturbing change in the situation would then be sure to be recorded as a slowing of response in the task. Such a test however is practically impossible. No subject works to the last notch. He may even think that he is doing so, but if something comes to call for more energy he finds he has a reserve force to fall back upon.

Since there is no test which taxes the subject to the last notch at every moment, and since resistance causes him to put forth more energy to combat it, and since introspective evidence does not record the true situation; no test will give the true effect of a situation upon a reagent unless some check is obtained as to the amount of effort exerted. Experiments may be made without such a check, and the experimenter may conclude that such and such a condition had no effect on a given task; but he cannot consistently go on and affirm that because such a task was not affected by the given condition, this condition is just as good for the performance of the task as other so-called normal conditions would be. If we have an engine running a certain piece of machinery at a certain speed when it is well oiled, and then instead of oil put sand on the bearings; the governor of the engine may see that it gets more steam and the speed remain unchanged, but we cannot conclude, because the speed is the same, that the sand is as good a lubricant as oil. If we measure the steam consumed, the pressure that the piston meets, or some such factor, we could tell. It is this error that has led a number of experimenters to decide that certain abnormal conditions are as conducive to efficient work as are normal conditions. If a factor is important it cannot be ignored simply because it involves difficulties.

SUMMARY OF CHAPTER

1. In a very unequivocal way it was found that the subjects struck the keys with greater force in a noisy than in a quiet situation.
2. This change in pressure is indicative of greater nervous tension at such times.
3. There is no strong correlation between the key pressure, breathing, and time scores; and this shows that they vary independently of each other and give records of different facts.
4. The value of the key pressure test lies in the fact that because the subject was not aware that it was being taken, it gave indications of changes in tension without the complication of variations due to voluntary effort to overcome the changes. It is also valuable in that it was connected directly with the task to be performed and was a real part of it.

CHAPTER VI

A COMPARISON OF THE EFFECTS OF VARIOUS NOISES

THE purpose of the experiment to be described in this chapter was to give the conclusions of the previous experiments a further test as well as to see if the measures there described could be used to distinguish the effects of different kinds of noise disturbances. The same noises were used and appear in the tables under the caption Bb. Besides this set, six graphophone records were played to each subject. The abbreviations used in the tables for these selections are as follows:

Am—concertina solo. ("Amoresque Waltz.")
Sh—ocarino solo. ("Swiss Shepherd.")
Li—humorous dialogue. ("Liars, or My Uncle's Farm.")
Mo—humorous monologue. ("How Mother Made the Soup.")
Ki—tenor solo. ("Killarney.")
Sa—bass solo. ("Sentinel Asleep.")

The task was the same as that described for the experiments in the preceding chapters. The procedure consisted in the subject making three hundred reactions under quiet conditions. The disturbances were then introduced and kept going continuously until all six of the records had been played and the set of noises administered.[1] (The noises were given for about the same length of time that it took to play a record.) After the entire gamut of disturbances had been traversed a second quiet period was given which lasted till the subject made one hundred reactions.

In order that no disturbance should have any advantage or disadvantage due to position, each subject received them in a different order. The order was chance and for each subject was as follows:

Subject	Disturbances						
Bl	Li	Bb	Ki	Am	Sa	Mo	Sh
Sp	Bb	Am	Mo	Li	Sh	Ki	Sa
Sa	Ki	Sa	Sh	Am	Li	Bb	Mo
Br	Am	Mo	Li	Sa	Bb	Ki	Sh
Bo	Sa	Sh	Bb	Li	Am	Ki	Mo
Ch	Mo	Li	Ki	Bb	Sa	Am	Sh
Cr	Sh	Ki	Mo	Am	Bb	Li	Sa
Re	Li	Am	Sh	Ki	Bb	Mo	Sa

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[1] We distinguish noises and graphophone records although in the tables they are all together classed as noises.

Subject	Disturbances						
Pf	Bb	Sa	Li	Mo	Ki	Sh	Am
Me	Ki	Mo	Bb	Sh	Sa	Am	Li
Ca	Am	Li	Sa	Ki	Mo	Sh	Bb
De	Mo	Sa	Bb	Li	Sh	Am	Ki
Hi	Sh	Mo	Am	Sa	Ki	Bb	Li
Kr	Bb	Sh	Li	Mo	Am	Sa	Ki
Ta	Sa	Ki	Am	Sh	Mo	Li	Bb

Records were taken of time, accuracy, breathing, and pressure exerted upon the keys throughout the entire set of experiments. The errors for a number of subjects was computed and in every case they were too few to be significant. The time scores were calculated as before (p. 23). The figures in Table XIII represent the time for ten reactions. The number below the average is the probable error (median deviation divided by the square root of the number of cases). Table XV shows the key pressure records in grams, each with its probable error. Table XVII gives the ratio of the expirations divided by the inspirations for the same subjects. Table XIX gives the time required for each complete respiration in seconds. The probable errors for the breathing and key pressure records likewise represent the median deviations divided by the square root of the number of cases. The first column of figures in the breathing tables represent the scores before the subject began work. In all four of these tables, namely XIII, XV, XVII and XIX, three columns of figures are given for the first quiet period, each figure being the average for one hundred reactions. Then follow seven columns giving the averages for the noise periods, which are arranged according to the disturbance used and do not represent the actual temporal sequence in which they were given. The last two columns are the averages for the last quiet period, each figure representing the average for fifty reactions. The averages at the foot of the tables represent the averages for the column under which it is placed, and the probable errors at the foot are the averages of the probable errors of the column.

In order that the results that these tables embody may be a little clearer and that no one subject shall have undue weight in the averages, we have arranged the results according to their relative positions and present them in tables XIV, XVI, XVIII, and XX. There are twelve scores reported for each subject, and in these tables they are arranged according to size from one to twelve. For example table fourteen shows that subject Bl made her fastest time in the first half of the last quiet period, the next fastest in the second half of the last quiet period, the third with the noise Sh, the fourth with noise Am, two tied for the fifth place (the last third of the first quiet period and noise Li) and so were given 5.5, the seventh Mo, etc. The averages in these tables are the average relative rankings for each position. The first figure below the average is the average deviation and below that the probable error, found by the formula;

$$\frac{\text{A.D. } .8453}{\sqrt{n}} = \text{P. E.}$$

In figures, 5, 6, 7, and 8 we represent graphically these relative rankings, with the range of reliability represented as the space between the dotted lines. The height of the curves is the relative ranking and the positions along the base the scores in the order that they appear in the original score tables.

It can be seen from the figures and from the curves that in the practice or first quiet period the time and key pressure records decrease, the breathing rate and ratio rise slightly. During the disturbance Bb, which was the set of harsh noises, the times are longer, the keys are struck much harder, the breathing ratio is greatly lengthened, while the breathing rate shows no reliable change. This accords with the findings of our previous experiments and thus corroborates the conclusions brought out in the preceding chapters. To the time records with the different graphophone records we can give no certain interpretation. Whatever the cause, better time was made during the instrumental selections than during the humorous speeches and vocal solos, and a little better also than in the final quiet period. The key pressure records show that the keys were struck harder all through the disturbances than either before or after. The breathing ratios show a notable lengthening throughout the noise period as compared with the quiet periods. The two graphophone records that show the fastest time show the highest key pressure record, and one of the two, Sh, the highest breathing ratio. The record Sa with the slowest time has the lowest key pressure record and the lowest breathing ratio record.

These comparisons show that those disturbances during which the time is accelerated are accompanied by increased key pressure and lengthened breathing ratios. Those disturbances during which the time is slower show not so much increase in key pressure and not so much lengthening of breathing ratio.

The breathing ratios become more significant when we mention the fact that all the subjects in this experiment except the first four in the tables were told not to speak during the experiment. This was done in order to see whether the change in breathing occurred when the lip movements were restrained. While they are not so radical as changes where the subjects were left free they are never-

TABLE XIII

Time Scores with Varied Noises

Subjects	*Quiet*			*Noises*							*Quiet*	
				Bb	Am	Sh	Li	Mo	Ki	La		
Bl	53.2	49.3	45.0	47.3	43.6	39.2	45.0	45.6	54.0	48.0	36.4	38.2
	2.1	*1.3*	*1.0*	*1.8*	*2.1*	*1.0*	*4.0*	*0.9*	*4.0*	*4.0*	*1.5*	*1.0*
Sp	41.3	41.7	37.6	38.4	37.3	37.1	38.0	36.8	35.7	34.4	34.8	33.6
	0.5	*1.0*	*0.8*	*1.5*	*1.7*	*1.8*	*1.9*	*1.8*	*1.3*	*0.3*	*0.5*	*0.6*
Sa	51.7	48.0	44.3	51.0	40.8	41.4	43.3	45.5	47.3	45.2	46.2	45.0
	1.8	*1.5*	*1.1*	*2.0*	*1.3*	*0.7*	*1.2*	*1.5*	*1.3*	*2.4*	*1.4*	*2.5*
Br	66.3	61.5	59.4	48.8	65.3	53.3	52.5	56.7	55.3	51.6	48.8	48.0
	1.4	*1.1*	*1.3*	*1.9*	*3.9*	*3.1*	*2.5*	*0.9*	*3.1*	*0.8*	*1.7*	*2.5*
Bo	73.4	68.6	64.5	55.7	53.8	55.0	54.3	55.7	55.3	58.3	56.6	59.2
	1.4	*1.0*	*0.8*	*1.4*	*1.0*	*0.7*	*1.6*	*1.9*	*3.6*	*1.3*	*1.5*	*0.8*
Ch	52.0	48.0	47.0	39.5	40.7	42.5	41.7	42.5	43.3	44.0	42.8	40.8
	0.9	*0.7*	*1.1*	*0.3*	*1.2*	*0.3*	*0.7*	*0.8*	*0.8*	*2.9*	*3.3*	*0.8*
Cr	54.5	53.9	53.1	53.5	49.7	51.2	51.3	49.3	50.0	51.7	51.0	51.8
	1.3	*2.5*	*1.6*	*0.6*	*1.6*	*0.2*	*1.9*	*1.5*	*0.3*	*0.7*	*4.5*	*0.8*
Re	71.8	66.3	67.5	77.0	60.7	66.0	80.0	70.7	74.5	72.5	70.4	71.0
	1.3	*0.7*	*1.1*	*2.7*	*0.4*	*1.1*	*4.9*	*0.5*	*2.5*	*2.5*	*2.0*	*2.5*
Pf	63.7	63.8	54.5	68.6	50.2	52.0	55.3	51.7	58.6	68.3	53.4	52.0
	1.5	*0.2*	*1.3*	*8.7*	*3.3*	*4.5*	*5.0*	*3.1*	*4.8*	*4.6*	*2.4*	*3.6*
Me	45.6	42.1	41.4	37.2	38.0	38.8	37.5	41.0	42.0	36.0	38.5	36.2
	1.1	*0.8*	*1.0*	*1.4*	*0.5*	*0.9*	*1.8*	*0.3*	*1.0*	*1.0*	*0.6*	*0.5*
Ca	47.5	46.9	50.1	50.0	50.5	47.5	60.7	59.7	45.2	49.3	41.4	41.8
	1.0	*2.1*	*2.5*	*4.0*	*4.3*	*4.8*	*7.1*	*4.1*	*2.5*	*3.9*	*2.0*	*0.9*
De	42.4	38.2	37.1	38.2	35.5	36.3	36.0	38.4	39.5	39.5	37.8	39.3
	0.5	*0.6*	*0.7*	*1.6*	*0.6*	*0.8*	*0.9*	*0.6*	*1.3*	*1.0*	*1.0*	*1.8*
Hi	45.6	43.1	43.3	37.8	40.8	38.6	39.2	42.0	37.5	40.5	38.8	38.1
	1.1	*0.8*	*0.5*	*0.6*	*0.5*	*1.1*	*1.9*	*0.7*	*1.0*	*0.5*	*0.7*	*0.7*
Kr	54.7	45.7	42.9	37.4	38.2	37.7	39.2	36.4	36.3	40.5	39.8	40.8
	1.1	*1.1*	*1.7*	*1.5*	*0.8*	*1.9*	*1.1*	*1.6*	*0.7*	*1.3*	*1.3*	*1.7*
Ta	52.2	49.9	51.5	46.0	46.5	50.7	64.6	42.5	49.2	56.3	45.2	53.8
	0.8	*0.7*	*1.0*	*2.0*	*1.8*	*1.1*	*2.6*	*1.0*	*0.3*	*0.4*	*2.1*	*1.9*
Av.	54.4	51.2	49.2	48.2	46.0	45.8	49.2	47.5	48.1	49.1	45.4	45.9
Av. of P.E.s	*1.2*	*1.1*	*1.1*	*2.1*	*1.7*	*1.6*	*2.6*	*1.4*	*1.9*	*1.8*	*1.8*	*1.5*

TABLE XIV

Relative Ranking of Time Scores

	Quiet			*Noises*							*Quiet*	
Subjects				Bb	Am	Sh	Li	Mo	Ki	Sa		
Bl	11	10	5.5	8	4	3	5.5	7	12	9	1	2
Sp	11	12	8	10	7	6	9	5	4	2	3	1
Sa	12	10	4	11	1	2	3	7	9	6	8	5
Br	12	10	9	2	11	6	5	8	7	4	3	1
Bo	12	11	10	5.5	1	3	2	5.5	4	8	7	9
Ch	12	11	10	1	2	5.5	4	5.5	8	9	7	3
Cr	12	11	9	10	2	5	6	1	3	7	4	8
Re	8	3	4	11	1	2	12	6	10	9	5	7
Pf	9	10	6	12	1	3.5	7	2	8	11	5	3.5
Me	12	11	9	3	5	7	4	8	10	1	6	2
Ca	5.5	4	9	8	10	5.5	12	11	3	7	1	2
De	12	6.5	4	6.5	1	3	2	8	10.5	10.5	5	9
Hi	12	10	11	2	8	4	6	9	1	7	5	3
Kr	12	11	10	3	5	4	6	2	1	8	7	9
Ta	9	6	8	3	4	7	12	1	5	11	2	10
Av.	10.8	9.1	7.8	6.4	4.2	4.4	6.4	5.7	6.4	7.3	4.6	4.9
A.D.	*1.4*	*2.2*	*2.0*	*3.4*	*3.4*	*1.4*	*2.7*	*3.6*	*3.1*	*2.3*	*1.8*	*2.9*
P.E.$_{t-0}$	*.31*	*.48*	*.44*	*.74*	*.75*	*.33*	*.59*	*.78*	*.68*	*.50*	*.39*	*.65*

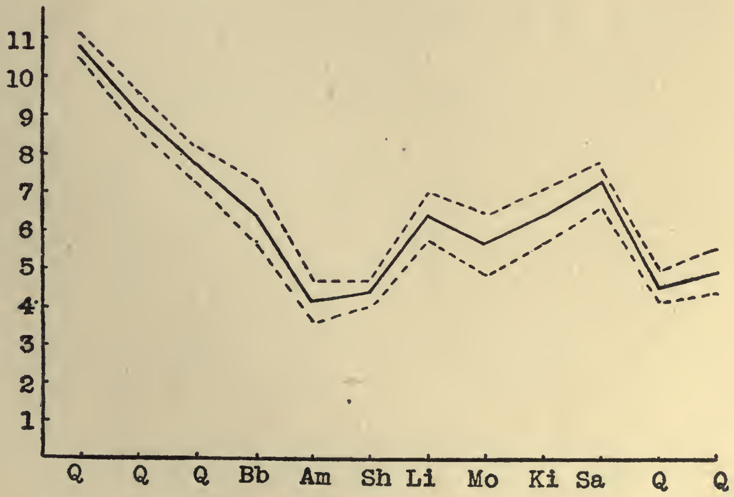

FIG. 5. Curve showing the relative ranking of the time scores. The probable errors are included within the dotted lines. The divisions along the base represent the quiet and noise periods. The order of the disturbances does not represent any time sequence.

TABLE XV

Key Pressure Scores with Varied Noises

	Quiet			*Noises*							*Quiet*	
Subjects				Bb	Am	Sh	Li	Mo	Ki	Sa		
Bl	380	240	250	330	280	250	270	250	342	313	220	210
	17	*4*	*3*	*3*	*7*	*2*	*5*	*3*	*3*	*4*	*4*	*5*
Sp	457	490	482	587	550	515	558	522	521	515	470	468
	3	*7*	*4*	*9*	*4*	*5*	*4*	*7*	*7*	*6*	*1*	*6*
Sa	580	585	565	407	560	610	540	350	620	590	290	265
	13	*8*	*8*	*5*	*10*	*5*	*10*	*5*	*10*	*14*	*10*	*6*
Br	570	442	333	444	423	393	358	375	355	351	338	304
	10	*7*	*10*	*10*	*9*	*20*	*10*	*9*	*6*	*17*	*12*	*12*
Bo	213	252	269	413	297	317	387	299	298	305	308	248
	3	*3*	*5*	*7*	*4*	*7*	*13*	*2*	*5*	*6*	*5*	*4*
Ch	450	233	141	368	195	162	139	205	166	196	158	144
	8	*7*	*4*	*15*	*5*	*6*	*6*	*12*	*8*	*14*	*5*	*10*
Cr	379	255	263	156	157	203	135	186	209	164	157	187
	5	*5*	*10*	*5*	*7*	*3*	*8*	*3*	*6*	*8*	*4*	*9*
Re	438	443	490	490	455	491	525	515	387	430	365	465
	9	*13*	*18*	*18*	*33*	*36*	*36*	*23*	*32*	*37*	*20*	*21*
Pf	712	730	640	765	630	595	565	628	587	585	605	620
	6	*6*	*7*	*8*	*10*	*6*	*12*	*9*	*14*	*15*	*10*	*9*
Me	1420	1525	1625	1605	1580	1625	1575	1605	1635	1640	1615	1454
	10	*6*	*5*	*5*	*14*	*8*	*15*	*6*	*8*	*7*	*8*	*22*
Ca	531	440	400	500	530	372	525	485	350	415	330	365
	11	*7*	*8*	*12*	*15*	*15*	*10*	*16*	*5*	*18*	*8*	*9*
De	190	150	150	205	195	195	205	190	185	180	155	175
	4	*3*	*4*	*5*	*4*	*5*	*6*	*4*	*5*	*5*	*4*	*4*
Hi	383	362	335	352	325	365	312	362	320	345	280	347
	1	*2*	*1*	*3*	*2*	*2*	*2*	*3*	*1*	*4*	*4*	*3*
Kr	325	275	260	358	315	340	345	315	300	280	197	260
	4	*3*	*5*	*3*	*6*	*4*	*5*	*6*	*7*	*7*	*7*	*5*
Ta	355	302	283	402	285	335	350	360	320	292	345	320
	3	*5*	*5*	*4*	*9*	*6*	*7*	*4*	*9*	*9*	*5*	*5*
Av.	492	448	432	492	452	450	452	442	439	440	388	384
Av. of Av. of P.E.s	*7*	*6*	*6*	*7*	*9*	*9*	*10*	*5*	*8*	*11*	*7*	*9*

TABLE XVI

RELATIVE RANKING OF KEY PRESSURE SCORES

	Quiet			*Noises*							*Quiet*	
Subjects				Bb	Am	Sh	Li	Mo	Ki	Sa		
Bl	12	3	5	10	8	5	7	5	11	9	2	1
Sp	1	5	4	12	10	6.5	11	9	8	6.5	3	2
Sa	8	9	7	4	6	11	5	3	12	10	2	1
Br	12	10	2	11	9	8	6	7	5	4	3	1
Bo	1	2	3	12	5	10	11	7	6	8	9	4
Ch	12	10	2	11	7	5	1	9	6	8	4	3
Cr	12	10	11	2	3.5	8	1	6	9	5	3.5	7
Re	4	5	8.5	8.5	6	10	12	11	2	3	1	7
Pf	10	11	9	12	8	4	1	7	3	2	5	6
Me	1	3	9.5	6.5	5	9.5	4	6.5	11	12	8	2
Ca	12	7	5	9	11	4	10	8	2	6	1	3
De	7.5	1.5	1.5	11	9.5	9.5	12	7.5	6	5	3	4
Hi	12	9.5	5	8	4	11	2	9.5	3	6	1	7
Kr	9	4	2.5	12	7.5	10	11	7.5	6	5	1	2.5
Ta	11	2	1	12	8	10	9	6	4	5	7	3
Av.	8.3	6.1	5.1	9.4	7.2	8.1	6.9	7.3	6.3	6.3	3.6	3.6
A.D.	*3.6*	*3.1*	*2.4*	*2.4*	*1.8*	*2.2*	*3.7*	*1.4*	*2.6*	*2.1*	*2.0*	*1.8*
P.E.$_{t-0}$	*.79*	*.68*	*.53*	*.53*	*.40*	*.48*	*.82*	*.31*	*.57*	*.46*	*.44*	*.40*

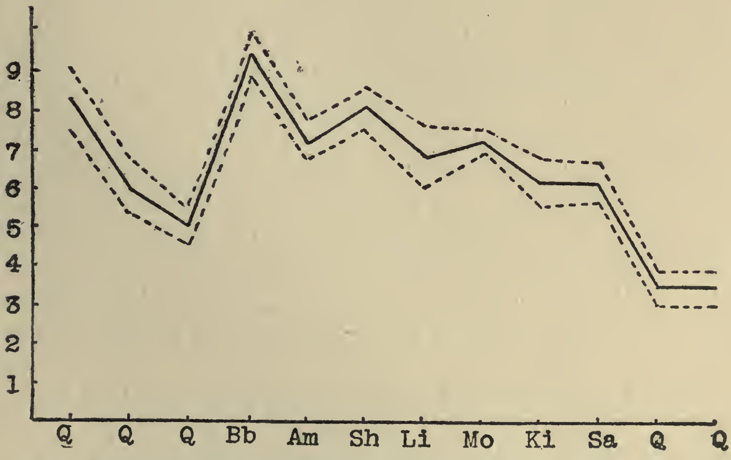

FIG. 6. Curve showing the relative ranking of the key pressure scores. The order of the disturbances does not represent any time sequence.

TABLE XVII

Breathing Ratio Scores with Varied Noises

	Before	*Quiet*			*Noises*							*Quiet*	
Subjects					Bb	Am	Sh	Ll	Mo	Kl	Sa		
Bl	1.77	2.97	2.23	1.90	3.86	2.75	1.97	2.82	2.22	2.50	3.02	1.76	2.05
		.09	*.06*	*.05*	*.26*	*.05*	*.15*	*.15*	*.11*	*.12*	*.19*	*.05*	*.09*
Sp	1.50	1.53	1.51	1.62	1.98	2.17	2.16	2.22	1.95	2.14	2.03	2.00	1.96
		.05	*.02*	*.02*	*.09*	*.05*	*.05*	*.03*	*.04*	*.06*	*.12*	*.03*	*.03*
Sa	1.53	3.08	3.30	4.43	3.79	6.18	5.05	4.10	4.78	4.58	4.64	3.04	4.33
		.21	*.20*	*.20*	*.24*	*.54*	*.51*	*.14*	*.13*	*.45*	*.34*	*.11*	*.50*
Br	1.70	2.87	2.68	2.93	4.02	2.70	3.47	3.46	2.84	3.02	3.18	2.63	2.79
		.14	*.12*	*.09*	*.33*	*.05*	*.16*	*.18*	*.08*	*.11*	*.25*	*.30*	*.15*
Bo	2.28	1.86	1.97	2.83	2.74	3.24	3.43	2.96	2.93	2.70	2.99	2.74	2.65
		.05	*.06*	*.13*	*.06*	*.20*	*.07*	*.34*	*.18*	*.13*	*.14*	*.06*	*.08*
Ch	3.20	3.18	4.05	3.39	7.53	3.95	4.09	3.66	4.68	4.27	5.49	4.19	4.02
		.20	*.18*	*.11*	*.56*	*.30*	*.09*	*.29*	*.44*	*.12*	*.41*	*.28*	*.31*
Cr	2.37	2.61	2.33	2.52	3.24	3.40	3.35	3.27	3.34	3.47	2.82	2.63	2.45
		.07	*.12*	*.30*	*.19*	*.06*	*.14*	*.08*	*.16*	*.20*	*.14*	*.04*	*.03*
Re	1.21	2.43	2.77	3.40	3.40	3.40	4.24	3.90	3.98	4.91	3.80	3.28	3.50
		.21	*.12*	*.06*	*.22*	*.32*	*.51*	*.18*	*.44*	*.31*	*.52*	*.19*	*.19*
Pf	1.78	3.60	4.07	3.51	3.82	3.78	3.83	3.72	4.05	3.99	3.51	4.53	4.36
		.24	*.10*	*.08*	*.13*	*.13*	*.19*	*.26*	*.20*	*.09*	*.22*	*.24*	*.29*
Me	1.57	2.31	2.54	2.83	2.39	3.51	4.07	2.95	3.62	2.88	3.48	2.50	2.48
		.10	*.09*	*.14*	*.28*	*.12*	*.33*	*.44*	*.40*	*.19*	*.26*	*.02*	*.02*
Ca	2.28	1.81	1.96	1.97	2.40	1.96	2.51	2.33	3.75	2.41	2.43	2.21	1.98
		.03	*.03*	*.04*	*.24*	*.03*	*.10*	*.18*	*1.08*	*.12*	*.15*	*.09*	*.04*
De	1.74	1.93	1.70	1.86	2.20	2.14	2.29	2.30	2.45	2.55	1.83	2.03	1.76
		.10	*.05*	*.05*	*.05*	*.09*	*.11*	*.10*	*.09*	*.14*	*.07*	*.07*	*.01*
Hi	2.80	2.61	3.00	3.02	4.14	4.22	3.99	4.92	3.98	3.85	3.98	3.91	2.84
		.19	*.10*	*.12*	*.25*	*.13*	*.17*	*.14*	*.16*	*.28*	*.08*	*.05*	*.13*
Kr	1.73	1.84	2.04	2.13	1.91	2.03	2.08	2.10	1.95	2.84	2.29	2.16	2.44
		.04	*.03*	*.08*	*.06*	*.06*	*.06*	*.10*	*.06*	*.05*	*.12*	*.03*	*.06*
Ta	2.51	6.88	4.19	3.93	10.51	6.06	6.50	6.19	5.28	4.32	4.77	5.52	4.20
		.21	*.65*	*.46*	*.69*	*.62*	*.41*	*.35*	*.22*	*.20*	*.30*	*.13*	*.86*
Av.	2.00	2.77	2.67	2.81	3.86	3.43	3.31	3.34	3.46	3.33	3.33	3.01	2.92
Av. of P.E.s		*.13*	*.13*	*.13*	*.24*	*.18*	*.20*	*.20*	*.25*	*.17*	*.23*	*.11*	*.19*

TABLE XVIII

RELATIVE RANKING OF BREATHING RATIO SCORES

	Quiet			*Noises*							*Quiet*	
Subjects				**Bb**	**Am**	**Sh**	**Li**	**Mo**	**Ki**	**Sa**		
Bl	10	6	2	12	8	3	9	5	7	11	1	4
Sp	2	1	3	6	11	10	12	4	9	8	7	5
Sa	2	3	7	4	12	11	5	10	8	9	1	6
Br	6	2	7	12	3	11	10	5	8	9	1	4
Bo	1	2	7	5.5	11	12	9	8	4	10	5.5	3
Ch	1	6	2	12	4	7	3	10	9	11	8	5
Cr	4	1	3	7	11	10	8	9	12	6	5	2
Re	1	2	5	5	5	11	9	10	12	8	3	7
Pf	3	10	1.5	6	5	7	4	9	8	1.5	12	11
Me	1	5	6	2	10	12	8	11	7	9	4	3
Ca	1	2	4	8	3	11	7	12	9	10	6	5
De	5	1	4	8	7	9	10	11	12	3	6	2
Hi	1	3	4	10	11	9	12	7.5	5	7.5	6	2
Kr	1	5	8	2	4	6	7	3	12	10	9	11
Ta	11	2	1	12	8	10	9	6	4	5	7	3
Av.	3.3	3.4	4.3	7.4	7.5	9.3	8.1	8.0	8.4	7.9	5.4	4.8
A.D.	*2.6*	*2.0*	*1.9*	*2.9*	*2.9*	*1.9*	*2.0*	*2.4*	*2.2*	*2.2*	*2.3*	*2.1*
P.E.$_{t-0}$	*.57*	*.44*	*.41*	*.64*	*.64*	*.42*	*.43*	*.52*	*.47*	*.47*	*.50*	*.46*

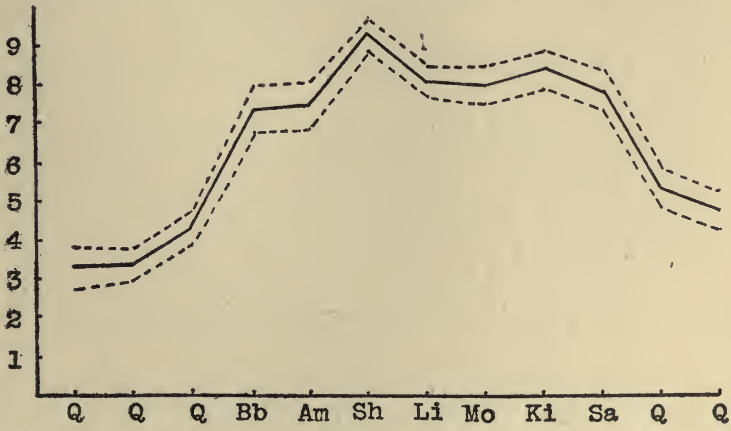

FIG. 7. Curve showing the relative ranking of the breathing ratio scores. The order of the disturbances does not represent any time sequence.

TABLE XIX

Breathing Rate Scores with Varied Noises

	Before	*Quiet*			*Noises*							*Quiet*	
Subjects					Bb	Am	Sh	Li	Mo	Ki	Sa		
Bl	3.42	3.55	3.46	3.47	4.08	3.15	2.98	4.41	4.03	3.60	3.70	3.22	3.67
		.11	*.02*	*.02*	*.34*	*.04*	*.01*	*.30*	*.10*	*.12*	*.15*	*.05*	*.10*
Sp	2.43	2.43	2.70	2.68	2.64	2.71	2.86	2.95	2.88	2.83	2.85	2.85	2.71
		.05	*.05*	*.04*	*.04*	*.22*	*.04*	*.02*	*.04*	*.08*	*.06*	*.06*	*.09*
Sa	3.00	3.50	4.35	4.53	3.44	5.42	4.94	5.28	5.00	4.12	4.72	4.55	5.06
		.12	*.18*	*.14*	*.14*	*.13*	*.35*	*.41*	*.04*	*.21*	*.30*	*.05*	*.10*
Br	3.41	3.76	3.97	4.27	5.84	3.60	4.13	4.14	3.86	3.96	4.45	4.29	4.16
		.08	*.11*	*.13*	*.42*	*.23*	*.23*	*.08*	*.12*	*.18*	*.42*	*.07*	*.23*
Bo	3.35	3.01	3.28	3.59	3.72	3.75	3.61	3.40	3.63	3.60	3.36	3.63	3.46
		.04	*.04*	*.09*	*.14*	*.17*	*.03*	*.06*	*.06*	*.12*	*.14*	*.03*	*.07*
Ch	3.41	4.42	5.24	4.38	4.45	4.50	4.76	4.27	4.26	4.35	4.54	4.68	4.30
		.25	*.09*	*.10*	*.19*	*.18*	*.23*	*.19*	*.12*	*.15*	*.23*	*.06*	*.18*
Cr	3.63	2.93	3.19	3.36	2.80	3.12	2.78	2.89	3.00	2.91	2.91	3.33	3.70
		.09	*.03*	*.03*	*.08*	*.05*	*.05*	*.05*	*.09*	*.05*	*.05*	*.08*	*.15*
Re	3.15	3.42	3.18	3.20	2.93	3.30	3.30	3.10	3.10	3.23	3.19	3.95	4.04
		.16	*.10*	*.06*	*.08*	*.17*	*.07*	*.10*	*.14*	*.14*	*.18*	*.05*	*.13*
Pf	2.70	3.17	3.42	3.28	2.36	2.45	2.64	2.48	2.87	2.61	3.02	3.49	3.53
		.17	*.05*	*.05*	*.10*	*.07*	*.14*	*.20*	*.23*	*.04*	*.12*	*.10*	*.06*
Me	3.00	3.50	3.56	3.33	2.44	3.87	4.37	3.31	3.53	2.87	3.42	3.28	3.47
		.08	*.10*	*.05*	*.08*	*.25*	*.08*	*.09*	*.30*	*.14*	*.04*	*.03*	*.06*
Ca	3.60	3.36	3.47	3.53	3.39	3.44	3.23	3.95	5.15	3.44	3.34	3.50	3.41
		.02	*.06*	*.07*	*.08*	*.03*	*.04*	*.18*	*.91*	*.07*	*.04*	*.03*	*.05*
De	2.92	2.54	2.48	2.58	3.05	2.58	2.79	3.07	2.77	3.14	2.69	2.98	2.88
		.10	*.01*	*.01*	*.07*	*.09*	*.07*	*.11*	*.08*	*.10*	*.09*	*.05*	*.03*
Hi	2.90	3.33	3.13	3.47	5.66	4.98	4.78	6.80	5.61	4.68	4.58	5.80	3.54
		.24	*.02*	*.14*	*.54*	*.18*	*.20*	*.05*	*.08*	*.28*	*.25*	*.08*	*.13*
Kr	2.81	2.70	2.63	2.78	2.25	2.62	2.75	2.81	2.77	2.77	2.81	2.72	2.84
		.03	*.02*	*.04*	*.11*	*.05*	*.11*	*.04*	*.05*	*.07*	*.05*	*.02*	*.07*
Ta	3.54	3.64	3.46	3.49	3.88	3.77	3.87	3.64	3.78	4.39	3.29	4.03	3.85
		.13	*.14*	*.27*	*.39*	*.31*	*.10*	*.08*	*.16*	*.26*	*.24*	*.24*	*.50*
Av.	3.21	3.33	3.43	3.46	3.53	3.54	3.58	3.76	3.74	3.50	3.52	3.75	3.64
Av. of P.E.s		*.11*	*.07*	*.08*	*.19*	*.15*	*.12*	*.13*	*.17*	*.13*	*.16*	*.07*	*.13*

TABLE XX

RELATIVE RANKING OF BREATHING RATE SCORES

	Quiet			*Noises*							*Quiet*	
Subjects				Bb	Am	Sh	Li	Mo	Ki	Sa		
Bl	6	4	5	11	2	1	12	10	7	9	3	8
Sp	1	4	3	2	5.5	10	12	11	7	8.5	8.5	5.5
Sa	2	4	5	1	12	8	11	9	3	7	6	10
Br	6	2	7	12	3	11	10	5	8	9	1	4
Bo	1	2	6	11	12	8	4	9.5	7	3	9.5	5
Ch	6	12	5	7	8	11	2	1	4	9	10	3
Cr	6	9	11	2	8	1	3	7	4.5	4.5	10	12
Re	10	4	6	2	8.5	8.5	2	2	7	5	11	12
Pf	8	10	9	1	2	5	3	6	4	7	11	12
Me	8	10	5	1	11	12	4	9	2	6	3	7
Ca	3	8	10	4	6	1	11	12	7	2	9	5
De	2	1	3.5	10	3.5	7	11	6	12	5	9	8
Hi	2	1	3	10	8	7	12	9	6	5	11	4
Kr	4	3	9	1	2	6	10.5	7.5	7.5	10.5	5	12
Ta	4.5	2	3	10	6	9	4.5	7	12	1	11	8
Av.	4.6	5.1	6.0	5.7	6.5	7.0	7.5	7.4	6.5	6.1	7.9	7.7
A.D.	*2.3*	*3.2*	*2.1*	*4.2*	*2.9*	*3.0*	*4.0*	*2.4*	*2.1*	*2.3*	*2.8*	*2.7*
P.E.$_{t-0}$	*.51*	*.70*	*.46*	*.91*	*.64*	*.65*	*.87*	*.52*	*.46*	*.50*	*.62*	*.59*

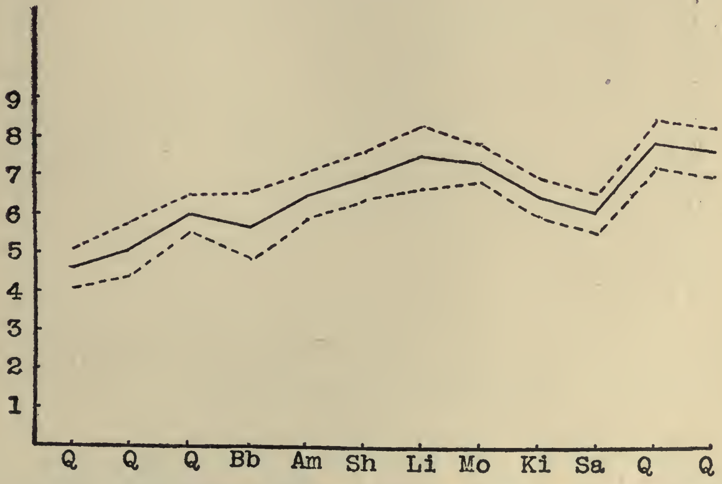

FIG. 8. Curve showing the relative ranking of the breathing rate scores. The order of the disturbances does not represent any time sequence.

TABLE XXI

RELATIVE RANKING OF TIME SCORES; NOISES IN THEIR CHRONOLOGICAL ORDER

Subjects	*Quiet*			*Noises*							*Quiet*	
Bl	11	10	5.5	5.5	8	12	4	9	7	3	1	2
Sp	11	12	8	10	7	5	9	6	4	2	3	1
Sa	12	10	4	9	6	2	1	3	11	7	8	5
Br	12	10	9	11	8	5	4	2	7	6	3	1
Bo	12	11	10	8	3	5.5	2	1	4	5.5	7	9
Ch	12	11	10	5.5	4	8	1	9	2	5.5	7	3
Cr	12	11	9	5	3	1	2	10	6	7	4	8
Re	8	3	4	12	1	2	10	11	6	9	5	7
Pf	9	10	6	12	11	7	2	8	3.5	1	5	3.5
Me	12	11	9	10	8	3	7	1	5	4	6	2
Ca	5.5	4	9	10	12	7	3	11	5.5	8	1	2
De	12	6.5	4	8	10.5	6.5	2	3	1	10.5	5	9
Hi	12	10	11	4	9	8	7	1	2	6	5	3
Kr	12	11	10	3	4	6	2	5	8	1	7	9
Ta	9	6	8	11	5	4	7	1	12	3	2	10
Av.	10.8	9.1	7.8	8.3	6.6	5.5	4.2	5.4	5.6	5.2	4.6	4.9
A.D.	*1.4*	*2.2*	*2.0*	*2.5*	*2.7*	*2.1*	*2.5*	*3.5*	*2.4*	*2.4*	*1.8*	*2.9*
P.E._{t-0}	*.31*	*.48*	*.44*	*.54*	*.59*	*.46*	*.54*	*.76*	*.52*	*.52*	*.39*	*.65*

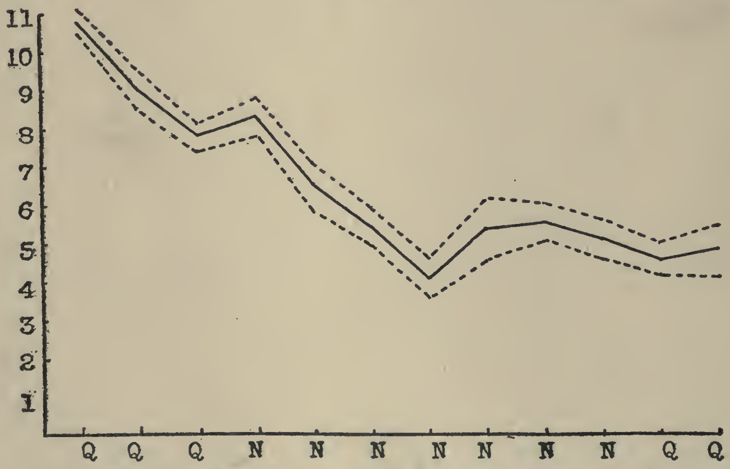

FIG. 9. Curve showing the relative ranking of the time scores with the noises in their chronological order represented along the base line.

theless significant. In several cases where the subjects were thus instructed it was noticed that the breathing records changed radically and in the manner that we had found was due to such lip movements. We then looked at the subjects through a small opening in the wall and found that they were moving their lips very slightly. When asked afterwards if they had done so, they all said they were not aware of having done so, showing that it is probable that subjects use this help in spite of themselves. The fact that changes in ratio occur (although not such radical changes) when there is no noticeable external movement seems to indicate

TABLE XXII

Relative Ranking of Key Pressure Scores; Noises in Their Chronological Order

Subjects	*Quiet*			*Noises*							*Quiet*	
Bl	12	3	5	7	10	11	8	9	5	5	2	1
Sp	1	5	4	12	10	9	11	6.5	8	6.5	3	2
Sa	8	9	7	12	10	11	6	5	4	3	2	1
Br	12	10	2	9	7	6	4	11	5	8	3	1
Bo	1	2	3	8	10	12	11	5	6	7	9	4
Ch	12	10	2	9	1	6	11	8	7	5	4	3
Cr	12	10	11	8	9	6	3.5	2	1	5	3.5	7
Re	4	5	8.5	12	6	10	2	8.5	11	3	1	7
Pf	10	11	9	12	2	1	7	3	4	8	5	6
Me	1	3	9.5	11	6.5	6.5	9.5	12	5	4	8	2
Ca	12	7	5	11	10	6	2	8	4	9	1	3
De	7.5	1.5	1.5	7.5	5	11	12	9.5	9.5	6	3	4
Hi	12	9.5	5	11	9.5	4	6	3	8	2	1	7
Kr	9	4	2.5	12	10	11	7.5	7.5	5	6	1	2.5
Ta	11	2	1	5	4	8	10	6	9	12	7	3
Av.	8.3	6.1	5.1	9.8	7.3	7.9	7.4	6.9	6.1	6.0	3.6	3.6
A.D.	*3.6*	*3.1*	*2.4*	*1.9*	*2.7*	*2.6*	*2.8*	*2.4*	*2.1*	*1.9*	*2.0*	*1.8*
P.E.$_{t-0}$	*.79*	*.68*	*.53*	*.42*	*.59*	*.57*	*.61*	*.52*	*.46*	*.42*	*.44*	*.40*

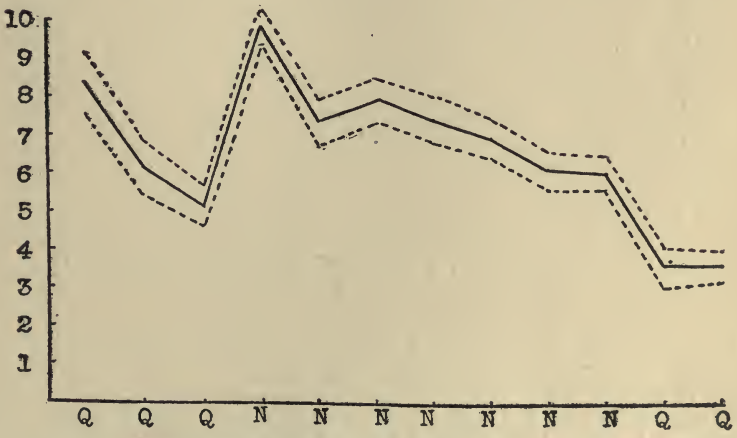

Fig. 10. Curve showing the relative ranking of the key pressure score with the quiet and noisy periods in their chronological order.

TABLE XXIII

Relative Ranking of Breathing Ratio Scores; Noises in Their Chronological Order

Subjects	Quiet			Noises							Quiet	
Bl	10	6	2	9	12	7	8	11	5	3	1	4
Sp	2	1	3	6	11	4	12	10	9	8	7	5
Sa	2	3	7	8	9	11	12	5	4	10	1	6
Br	6	2	7	3	5	10	9	12	8	11	1	4
Bo	1	2	7	10	12	5.5	9	11	4	8	5.5	3
Ch	1	6	2	10	3	9	12	11	4	7	8	5
Cr	4	1	3	10	12	9	11	7	8	6	5	2
Re	1	2	5	9	5	11	12	5	10	8	3	7
Pf	3	10	1.5	6	1.5	4	9	8	7	5	12	11
Me	1	5	6	7	11	2	12	9	10	8	4	3
Ca	1	2	4	3	7	10	9	12	11	8	6	5
De	5	1	4	11	3	8	10	9	7	12	6	2
Hi	1	3	4	9	7.5	11	7.5	5	10	12	6	2
Kr	1	5	8	2	6	7	3	4	10	12	9	11
Ta	11	2	1	5	4	8	10	6	9	12	7	3
Av.	3.3	3.4	4.3	7.2	7.3	7.8	9.7	8.3	7.7	8.7	5.4	4.8
A.D.	*2.6*	*2.0*	*1.9*	*2.5*	*3.1*	*2.4*	*1.8*	*2.5*	*2.1*	*2.2*	*2.3*	*2.1*
P.E.$_{t-0}$	*.57*	*.44*	*.41*	*.54*	*.68*	*.52*	*.39*	*.54*	*.46*	*.48*	*.50*	*.46*

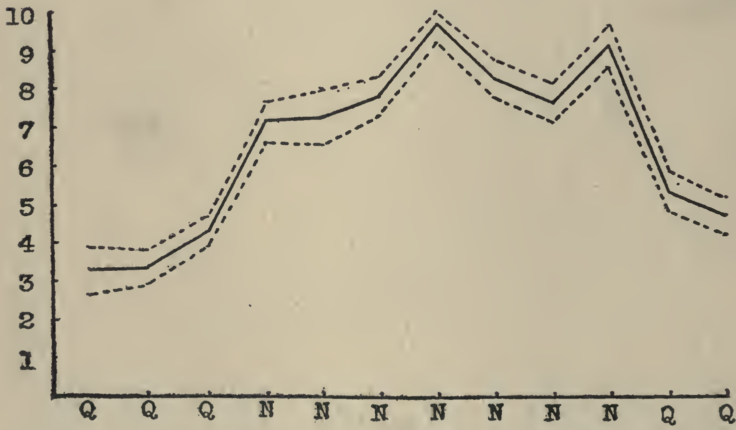

Fig. 11. Curve showing the relative ranking of the breathing ratio scores with the quiet and noisy periods in their chronological order.

that even faint movements of the inner organs of articulation have the effect of increasing the breathing ratio.

In Tables XXI, XXII, XXIII and XXIV we have arranged the relative ranking of these same scores chronologically. In each of the tables the first three columns represent the first quiet period of three hundred reactions; the next seven columns are the noises in the order in which they were presented for each subject; the last two columns represent the last quiet period. Below are the averages, average deviations and probable errors.

Despite the fact that with this arrangement the different noises are averaged together we get some significant results. The time record outside of a retardation at the beginning of the noises shows a continual drop till the middle of the disturbance period when it strikes a level. The drop is doubtless due to practise, for in this

TABLE XXIV

RELATIVE RANKING OF BREATHING RATE SCORES. NOISES IN THEIR CHRONOLOGICAL ORDER

Subjects	*Quiet*			*Noises*							*Quiet*	
Bl	6	4	5	12	11	7	2	9	10	1	3	8
Sp	1	4	3	2	5.5	11	12	10	7	8.5	8.5	5.5
Sa	2	4	5	3	7	8	12	11	1	9	6	10
Br	6	2	7	3	5	10	9	12	8	11	1	4
Bo	1	2	6	3	8	11	4	12	7	9.5	9.5	5
Ch	6	12	5	1	2	4	7	9	8	11	10	3
Cr	6	9	11	1	4.5	7	8	2	3	4.5	10	12
Re	10	4	6	2	8.5	8.5	7	2	2	5	11	12
Pf	8	10	9	1	7	3	6	4	5	2	11	12
Me	8	10	5	2	9	1	12	6	11	4	3	7
Ca	3	8	10	6	11	2	7	12	1	4	9	5
De	2	1	3.5	6	5	10	11	7	3.5	12	9	8
Hi	2	1	3	7	9	8	5	6	10	12	11	4
Kr	4	3	9	1	6	10.5	7.5	2	10.5	7.5	5	12
Ta	4.5	2	3	1	12	6	9	7	4.5	10	11	8
Av.	4.6	5.1	6.0	3.4	7.4	7.1	7.9	7.4	6.1	7.4	7.8	7.7
A.D.	*2.4*	*3.1*	*2.1*	*2.3*	*2.2*	*2.7*	*2.4*	*2.9*	*4.6*	*3.2*	*2.9*	*2.7*
P.E.$_{t-0}$	*.52*	*.68*	*.46*	*.5*	*.5*	*.6*	*.5*	*.6*	*1.0*	*.7*	*.6*	*.6*

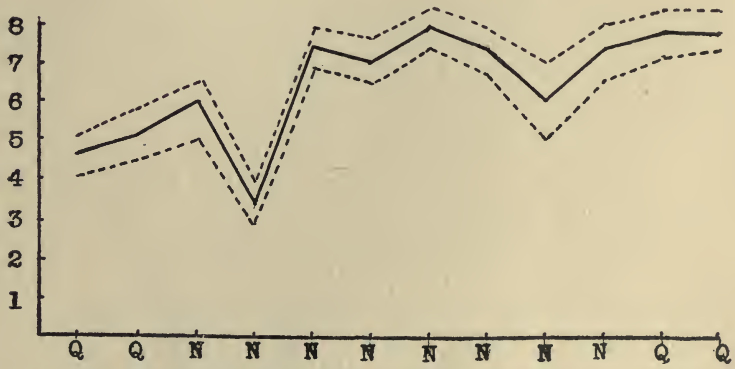

FIG. 12. Curve showing the relative ranking of the breathing rate scores with the quiet and noisy periods in their chronological order.

set of experiments instead of giving a practise period of four hundred reactions as we did in the earlier experiments, we gave only three hundred. It is significant to see that the curve drops regardless of the noises till the level is reached, which level is kept during the noises as well as during the ensuing quiet. Certainly if we had nothing but a time record we would have to conclude the noises had very little effect upon the work.

When we look at the key pressure and breathing ratio records we get a different story. The noises cause a marked increase of key pressure at the first. The pressure then decreases gradually, but remains much higher all through the disturbance period than it is after the noises stop. While the breathing ratio also increases at the beginning of the noise period, it reaches its maximum at the middle. The breathing rate when taken as a whole shows a gradual decrease. This is probably due to an outside factor. When the subjects began work it was just after climbing three flights of stairs. This bodily exertion followed by a period of almost complete physical inactivity probably is the cause of this general change in the breathing rate. One change that does seem significant, although taken by itself probably it would not prove anything definite, is the fact that at the beginning of the noise the rate increases. This with the other evidence we have is doubtless indicative of the exciting effect of the first introduction of the noises.

These four records bear out precisely our former findings, and show that the case with the majority of the subjects is somewhat as follows:

When the noises first come on they experience a disorientation which affects the time score somewhat. They then strain to overcome the effect of the disturbance and cast about for some help. While some hit upon articulation at the start, a large number do not do so until the disturbance has been going for some time. When they adopt this help and find they are making as good time they do not have to strain quite so hard, although they are under a greater tension by far than during quiet.

These tables also show that the effects of different noises are not so different as one might suppose. It is more a case of meeting a new situation, orienting oneself properly and adapting oneself to the new condition. We can not say just how much effect a certain noise will have, but we can say that when a disturbance comes it will be definitely met and combated. This overcoming may be through extra strain, using some factor that before was not utilized, or the using of some factor that was used before but now to a greater degree, or it may be through the combination of both the strain and the outside help.

Summary.—The experiments in this chapter corroborate the findings of previous experiments and show that:

1. The time records taken by themselves are of little significance except that they show an initial retardation in the noise period.

2. The key pressure records show that greater effort was exerted throughout the noise period. This tension is greater with the harsh noises than with the graphophone records. The tables giving the chronological order show that the tension was greater at the beginning of the noise period than at the end.

3. The breathing ratios show also an increase throughout the noise period. A significant feature of this record is that it reaches its highest point about the middle of the noise period, indicating that it takes most of the subjects some time to discover the aid of articulation for overcoming the noise effects.

4. The breathing rate shows a significant increase at the beginning of the noise period.

5. These records taken together show that at the first intrusion of the disturbances the subject is confused (see time record), he is somewhat excited by the disturbances (breathing rate), and strains to overcome it (key pressure record). The attempt to overcome it in most subjects leads to articulation, which in the majority of cases is not struck upon as an aid at once. With the help of this strain and articulation the time effect of the noises disappears and the subject attains or even exceeds his former speed.

CHAPTER VII

Relative Significance of Changes in Time and Force

The foregoing experiments seemed to show that the influence of certain conditions upon a person's response is not revealed by measuring the time consumed in performing identical tasks under the different conditions. We have seen that increasing one's effort and calling in aids to combat the more difficult situation are the more significant factors. Now the assumption at the basis of most of the work on the effect of conditions upon activity is that the force exerted by the subject is the same under all circumstances; that if the subject is instructed to do his best, he *will* do his best unless he is an unusually obstinate creature. If this is so, then the only factor left to change is the time factor; therefore any change in the time is indicative of the effect of the changed condition, and no change in time is evidence that the condition has no effect. This may be good reasoning in a purely physical or physiological experiment but it can not be shown to hold in a psychological experiment. For instance if one should take the gastrocnemius muscle of a frog, he could show that the contraction of the muscle is directly proportional to the stimulation. He could also show that it is inversely proportional to the load it has to lift. If instead of a simple muscle one should take a decapitated frog the situation would be a little more complicated. A little acid placed on the breast would cause a contraction of the leg. If the leg is held the pull will be stronger. If the restrained leg fails altogether to overcome the restraining force the other leg will be used, and if both are held convulsive movements of the whole body will result. Still greater would be the increase in response of a normal frog. To hold its legs and stimulate it as before with acid would cause a riot of responses. If the case is so complicated with a frog, why should a normal human being, in a psychological experiment, be classed as a simple gastrocnemius muscle.

In order to bring out the time and force relations, to see how each changes as the task becomes harder or easier, an experiment was devised in which all the factors could be accurately measured. The method, in brief, was to have the subject raise a measurable weight a measurable distance in a measurable time. From these three the force could be computed, and the relations observed between the responses to the varying weights. The movement used was the flexion of the arm. The handle, which the subject grasped for the pull, was about on a level with the diaphragm. The subject stood with the arm extended to the front and when the signal was given drew the handle to the body. He was told plainly that what was to be measured was not the quickness of his response to the signal, but the force with which he pulled the weight over the space. He was instructed to use all his force all the time.

It can be seen that such an experiment required a sturdy piece of apparatus. On a stout table whose top stood 111 cm. from the floor was arranged a pair of grooved oak boards in which ran a light carriage which operated electric contacts. To one end of this carriage was attached the rope leading to the handle which the subject grasped, while from the other end a rope passed over a stout iron pulley (which ran very freely) and was fastened to the weight holder. This weight holder was made so that the weights could be readily changed. A rope was attached from the weight holder through a spring to the floor, long enough to allow the carriage to move fifty centimeters. The electric contact which started the chronoscope was at the very beginning of the movement of the carriage, the contact which stopped it forty-six centimeters from the beginning. As the total movement possible was fifty centimeters it can be seen that the chronoscope was stopped before the end of of the movement. It was thought advisable to arrange it this way so that the subject would not tend to regulate his pull to the distance and slow up before the last contact was operated. The spring which connected the rope to the floor took up the shock that must come at the end of a rapid movement.

The time was measured by a Hipp Chronoscope, which was wired according to the method outlined by Dunlap,[1] was carefully tested and gave very accurate readings.

The weights were calibrated with great care, and counting the weight holder weighed 2001, 3105, 3546, 4660, 5106, and 6220 grams. We then had a definite distance over which the weights were to be moved, we knew exactly how heavy each weight was, and we could measure just how long each movement took.

Eleven men subjects took part in the first set of experiments, each subject making one hundred reactions in one session. Ten pulls were made with one weight and then the weight was changed. The order in which the weights were given was: 6220, 5106, 4660, 3546, 3105, 2001, 6220, 3105, 4660 and 6220. The time consumed in reading the chronoscope and in adjusting the contacts gave the subject a rest between each pull so that fatigue did not enter in to any noticeable extent. In the beginning of each experiment period the subject was allowed to make six pulls for which the readings were recorded as in the later trials but were not used in the averages presented in the tables. This was to give him an opportunity to adapt himself to the new task.

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[1] Dunlap, K., "The Hipp Chronoscope Without Armature Springs," *British Jour. of Psychol.*, 1912, *5*, 1–7.

For each set of ten the average time was found and the probable error by the formula:

$$\frac{\text{A.D. } .8543}{\sqrt{n}} \equiv \text{P. E.}$$

In Table XXV are given the time scores in sigma (thousandths of a second) with the probable errors below each average. In the second section of the table are given the averages for each weight used. It will be seen that as the weight was decreased the time dropped from 220.6 sigma to 190.7 sigma. After the abrupt increase of the weight from 2,001 to 6,220 grams the time rose to 216.2 sigma. On the reduction of the weight to 3,105 grams it again fell to 190 sigma, and as the weight was increased the time also rose. Moreover it may seem from the second part of the table that when all the measures for the different weights are averaged together there is a fairly regular change in time as the weights change.

Now this looks as though these time records were a perfectly good indication of the change of weight. The time for weight 5106 is the only exception to a general correspondence between the weight change and the time change. Suppose however that we take it for granted that the force used all through was the same, for the reason that we told the subjects to do their best. Suppose that on the basis of this assumption we measure the differences in the weights used through the differences in time. We shall get very different results from what we know to be the real weight differences.

The formulæ to use in such a case are two. The first is that the acceleration of a body is equal to twice the distance traversed divided by the square of the time consumed; assuming that the body starts from rest, as it did in this case. After we have the acceleration we can find the force in dynes by the second formula, which is; that force, in dynes, is equal to the product of the mass by the acceleration plus the product of the mass by the acceleration of gravity, or 980 centimeters per second.

$$\text{Acceleration} \equiv \frac{2 \times \text{space}}{(\text{time})^2}.$$

$$\text{Force} \equiv \text{Mass} \times \text{acceleration} + \text{Mass} \times 980.$$

Now if we suppose that the force used throughout was 12,500,000

TABLE XXV

Time Records for Weight-Pulling Experiments

	Weights									
Subjects	6220	5106	4660	3546	3105	2001	6220	3105	4660	6220
Ja	225.0	197.3	219.0	256.4	224.8	240.2	227.6	184.7	199.2	219.3
	5.1	*6.9*	*4.8*	*5.6*	*5.1*	*6.9*	*4.8*	*4.8*	*5.6*	*1.6*
Is	204.6	186.6	189.8	184.8	180.3	165.7	217.4	170.3	195.4	221.4
	2.4	*1.8*	*1.1*	*2.1*	*1.1*	*1.9*	*2.1*	*2.6*	*2.1*	*1.3*
Li	221.6	187.7	187.5	192.3	177.5	154.3	194.8	166.7	184.7	195.2
	2.4	*1.8*	*2.0*	*2.2*	*2.4*	*1.5*	*2.1*	*2.8*	*2.6*	*1.7*
Si	261.3	245.7	229.8	220.9	212.2	206.7	222.1	225.9	250.3	259.3
	2.7	*5.4*	*1.9*	*1.7*	*1.1*	*2.7*	*1.3*	*2.4*	*2.5*	*3.6*
Wi	180.3	168.0	162.0	150.6	154.3	136.4	171.6	132.3	152.5	162.3
	1.7	*1.1*	*1.6*	*1.6*	*1.6*	*1.0*	*1.3*	*1.1*	*1.2*	*1.8*
Bn	180.6	161.3	156.1	140.7	161.0	163.0	192.5	156.6	181.2	191.9
	2.7	*2.4*	*1.9*	*3.3*	*1.8*	*3.0*	*3.1*	*4.8*	*2.8*	*2.6*
Sr	198.7	189.5	185.6	168.2	175.1	162.8	199.5	177.5	200.1	231.5
	2.5	*2.8*	*2.3*	*1.0*	*2.6*	*3.1*	*2.2*	*4.2*	*4.7*	*2.8*
Ke	315.9	262.4	302.2	318.9	329.4	319.4	314.9	321.6	355.6	356.4
	7.7	*4.2*	*4.4*	*6.8*	*7.4*	*8.1*	*4.6*	*6.0*	*6.0*	*5.2*
Bh	204.4	213.1	202.2	188.4	186.3	190.8	231.9	190.9	211.1	227.0
	2.0	*2.0*	*1.2*	*2.3*	*0.9*	*2.2*	*2.5*	*2.6*	*1.8*	*1.8*
Hn	217.2	213.7	198.1	176.3	169.8	155.6	181.8	157.4	176.1	188.0
	2.3	*6.0*	*1.6*	*2.8*	*1.0*	*1.4*	*1.6*	*1.2*	*3.4*	*1.8*
Sl	216.6	212.6	231.3	223.2	222.0	202.9	224.7	206.7	230.4	238.4
	1.7	*3.1*	*2.5*	*3.8*	*3.5*	*2.8*	*2.0*	*2.1*	*3.3*	*3.0*
Av.	220.6	203.4	205.8	201.9	199.3	190.7	216.2	190.0	212.4	226.4
Av. of P.E.s	*3.0*	*3.4*	*2.3*	*3.0*	*2.6*	*3.1*	*2.5*	*3.1*	*3.3*	*2.5*

Above Data Arranged According to Weights

	Weights					
Subjects	6220	5106	4660	3546	3105	2001
Ja	223.9	197.3	209.1	256.4	204.7	240.2
Is	214.4	186.3	192.6	184.8	175.3	165.7
Li	203.8	187.7	186.1	192.3	172.1	154.3
Si	247.6	245.7	240.0	220.9	219.0	206.7
Wi	171.4	168.0	157.2	150.6	143.3	136.4
Bn	188.3	161.3	168.6	140.7	158.8	163.0
Sr	209.9	189.5	192.8	168.2	176.3	162.8
Ke	329.1	262.4	328.9	318.9	325.5	319.4
Bh	221.1	213.1	206.6	188.4	188.6	190.8
Hn	195.7	213.7	187.1	176.3	163.6	155.6
Sl	226.6	212.6	230.8	223.2	214.3	202.9
Av.	221.1	203.4	209.1	201.9	194.7	190.7

dynes, which is about the average force we found actually used, and from the times compute the weights used we will get the following:

Time	Weights Found	Actual Weights
190.7	3550	2001
194.7	3670	3105
201.9	3860	3546
209.1	4040	4660
203.4	3910	5106
221.1	4370	6220

This shows at once the fallacy of depending on time measures to find the changes in conditions. The actual weights varied from 2,001 to 6,220 grams, the heavy one being three times the lightest one, there being an actual difference of 4,219 grams. In the weights found from an experiment based on the assumption of equal force being used the weights varied from 3,550 to 4,370 grams, an actual difference of only 820 grams, the heaviest being only 1.23 times the lightest.

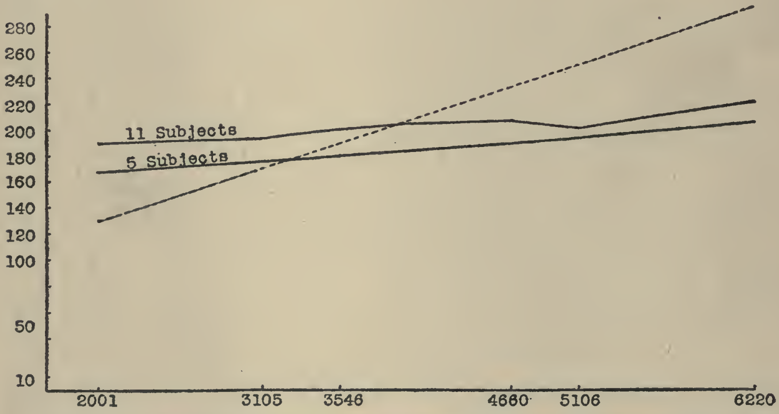

FIG. 13. Graph to illustrate the significance of time measurements. The height of the curve represents time in sigma. The divisions along the base the various weights used. The dotted line represents the times that would be required to raise the different weights 46 cm. if the force used was constantly 12,500,000 dynes. The solid lines represent times that were required in actual experiments. Each line is the result of a different experiment.

The thing may be expressed a little differently. In Fig. 13 the dotted line represents by its distance from the base the time that it would take to pull up the weights represented at the base if the force used throughout was 12,500,000 dynes. The solid lines represent the times that were actually consumed in pulling up the given weights. (The line marked "five subjects" represents the

TABLE XXVI

FORCE RECORDS FOR WEIGHT-PULLING EXPERIMENT

	Weights									
Subjects	6220	5106	4660	3546	3105	2001	6220	3105	4660	6220
Ja	17.35	17.02	13.50	8.44	8.70	5.17	17.10	11.44	15.40	17.95
	.50	*.75*	*.40*	*.22*	*.29*	*.20*	*.51*	*.43*	*.63*	*.19*
Is	19.70	18.55	16.40	13.03	11.81	8.72	18.20	12.88	15.80	17.70
	.33	*.25*	*.15*	*.22*	*.09*	*.15*	*.25*	*.32*	*.24*	*.14*
Li	17.64	18.30	16.75	12.30	12.10	9.78	21.20	13.30	17.18	21.10
	.24	*.25*	*.27*	*.23*	*.22*	*.15*	*.33*	*.35*	*.36*	*.26*
Si	14.42	12.75	12.65	10.17	9.43	6.32	17.62	8.62	11.40	14.60
	.16	*.32*	*.14*	*.11*	*.06*	*.12*	*.13*	*.12*	*.14*	*.25*
Wi	23.55	21.65	20.90	17.90	15.08	11.82	25.46	19.35	23.05	27.80
	.30	*.22*	*.30*	*.28*	*.25*	*.16*	*.32*	*.27*	*.28*	*.49*
Bn	23.60	22.95	22.20	19.60	14.08	8.94	21.50	14.70	17.60	21.60
	.54	*.49*	*.44*	*.58*	*.22*	*.24*	*.48*	*.74*	*.42*	*.40*
Sr	20.50	18.00	17.00	15.02	12.35	8.95	20.45	12.10	15.26	16.70
	.39	*.41*	*.31*	*.14*	*.24*	*.25*	*.34*	*.43*	*.53*	*.18*
Ke	11.95	11.80	9.11	6.67	5.68	3.78	11.83	5.80	7.97	10.56
	.29	*.21*	*.14*	*.14*	*.11*	*.10*	*.17*	*.11*	*.11*	*.13*
Bh	19.70	15.35	14.86	12.65	11.30	7.04	16.70	10.85	14.15	17.15
	.27	*.19*	*.12*	*.24*	*.08*	*.10*	*.22*	*.23*	*.16*	*.18*
Hn	18.15	15.30	15.30	14.00	12.90	9.65	23.35	14.55	18.40	22.25
	.25	*.58*	*.19*	*.40*	*.13*	*.14*	*.28*	*.19*	*.52*	*.32*
Sl	18.20	15.40	12.40	10.03	8.85	6.45	17.40	9.75	12.60	16.15
	.15	*.29*	*.16*	*.24*	*.19*	*.12*	*.21*	*.14*	*.21*	*.26*
Av.	18.61	17.01	15.55	12.71	11.12	7.87	19.16	12.12	15.35	18.51
Av. of P.E.s	*.31*	*.36*	*.24*	*.25*	*.16*	*.16*	*.29*	*.30*	*.33*	*.25*

ABOVE DATA ARRANGED ACCORDING TO WEIGHTS

	Weights					
Subjects	6220	5106	4660	3546	3105	2001
Ja	17.47	17.02	14.45	8.44	10.07	5.17
Is	18.53	18.55	16.10	13.03	12.34	8.72
Li	19.98	18.30	16.96	12.30	12.70	9.78
Si	15.54	12.75	12.02	10.17	9.02	6.32
Wi	25.60	21.65	21.98	17.90	17.22	11.82
Bn	22.23	22.95	19.90	19.60	14.39	8.94
Sr	19.22	18.00	16.13	15.02	12.22	8.95
Ke	11.45	11.80	8.54	6.67	5.74	3.78
Bh	17.85	15.35	14.50	12.65	11.07	7.04
Hn	21.25	15.30	16.85	14.00	13.72	9.65
Sl	17.25	15.40	12.50	10.03	9.30	6.45
Av.	17.85	17.01	15.45	12.71	11.62	7.87

results of an experiment to be described presently.) It can be seen that the two do not by any means coincide. The times have a tendency to equality showing that the subject tends to keep constant the time for pulling the weights at the expense of the force.

In order to see more clearly the significance of the force exerted let us look at Table XXVI. This table represents the force used by the eleven subjects in pulling up the weigths as described above, the unit being one million dynes. In the second part of the table the totals for each weight for each subject are given. These forces were obtained by the use of the two formulæ given above. It is evident that the force used varies more significantly than the time. In Fig. 14 we give in the dotted line the force that would need to be exerted if the time were kept at 205 sigma throughout the experiment. It will be seen that the solid lines, which represent the actual force used for the various weights, more nearly follow the dotted line than did the time line in Fig. 13. In other words the subjects tend to change the force used in order to keep the time nearly constant.

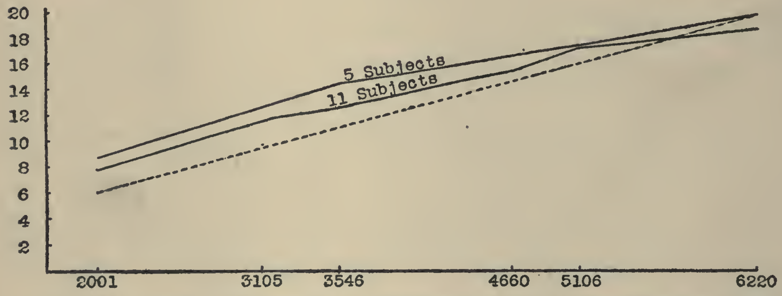

FIG. 14. Graph to illustrate the significance of force measurements. The height of the curve represents force in million dynes, the divisions along the base the various weights used. The dotted line represents the force that would be required to raise the different weights if the time were constantly kept at 205 sigma. The two solid lines represent the forces that were actually used by subjects in two different experiments.

We may mention another feature of the experiment that illustrates this point. As we decreased the weights by degrees the subjects decreased their force considerably. In three casees out of the eleven this decrease was so great that, when the weight was changed from 2,001 to 6,220 grams, the force they were using was not sufficient to pull up the heavy weight, and they failed to make a score. In those cases where they did pull it up, it invariably took a longer time than the second pull with the heavy weight. We will give the times for the first and second pulls on the 6,220 weight immediately following the 2,001:

	First Pull		*Second Pull*	
Subject	Time	Force	Time	Force
Ja	268	14.6	244	15.7
Is	330	11.3	191	21.7
Li	297	12.4	183	23.7
Si	failed	6.1 or less	222	17.7
Wi	208	20.3	176	24.5
Bn	279	13.4	193	21.4
Sr	353	10.6	201	20.2
Ke	failed	6.1 or less	269	14.0
Bh	248	15.4	218	18.1
Hn	246	15.5	166	26.8
Sl	failed	6.1 or less	227	17.2

These first reactions were not counted in the averages given in the table. We always gave eleven pulls on the heavy weight following the lightest. They were kept separate and are given here to show that the subjects adjust their energy to the difficulty of the task. The subject works at a regular rate thinking that he is doing his best, but when the increased weight comes, he buckles down and tries to keep up his former pace.

One more incident in connection with this experiment is worthy of note. Subject Si in his very first pull made a score with the weight 6,220 grams of 100 sigma. He threw himself into it with all his might. When it came up so quickly he expressed his surprise that the weight was no heavier, and his next trial was 371 sigma. He was then told to do his best and pull all the time as hard as he did the first trial, but either he could not or would not, for his times range from 206 to 261 sigma. This again goes to show that a subject expends energy in proportion to the idea he has of the difficulty of the task.

In order to make sure that the results of this experiment were not dependent upon the method of procedure we performed a second experiment, in which each subject made only ten pulls each day (and with the same weight) and worked only two periods a week. The first day the weight used was 3,542, the second 6,220, the third 2,002, and the fourth day 5,106 grams. There were five subjects, two women and three men. Both the time (in sigma) and force (unit of one million dynes) results of this experiment are given in Table XXVII, and the curves are plotted in Figs. 13 and 14. With a procedure of this nature we should expect more irregularity than in a one period method due to the fact that the subject may set a different pace for himself on different days on account of differences in physical or mental condition. This is actually so, and while the total averages show the same results as the single period method the individual cases present more irregularities.

TABLE XXVII

SCORES FOR WEIGHT-PULLING EXPERIMENT

(One Weight Used for each Sitting)

Time Scores

	Weights			
Subjects	3542	6220	2001	5106
Mg	231.0	241.7	212.7	212.4
	1.4	*3.0*	*1.8*	*0.7*
Vg	161.5	208.3	156.8	210.4
	1.5	*2.1*	*1.6*	*0.9*
Kd	225.1	234.4	190.9	210.4
	3.6	*2.0*	*3.1*	*1.3*
Gy	141.1	170.3	144.5	174.2
	2.5	*1.4*	*2.2*	*2.0*
Pn	146.2	187.5	139.2	177.1
	1.0	*1.4*	*1.4*	*1.3*
Av.	181.0	208.4	168.8	196.9
Av. of P.E.s	*2.0*	*2.0*	*2.0*	*1.2*

Force Scores

Subjects	3542	6220	2001	5106
Mg	9.11	15.80	6.03	15.40
	.07	*.24*	*.07*	*.07*
Vg	15.98	19.20	9.47	15.55
	.25	*.28*	*.16*	*.09*
Kd	9.42	16.43	7.00	15.55
	.21	*.18*	*.17*	*.12*
Gy	19.55	25.70	10.68	20.40
	.44	*.35*	*.22*	*.34*
Pn	18.62	22.25	11.21	19.88
	.18	*.24*	*.19*	*.22*
Av.	14.53	19.87	8.88	17.36
Av. of P.E.s	*.23*	*.26*	*.16*	*.17*

In tests where the influence of some factor has been the object of investigation one method has been to endeavor to keep the subject in ignorance of the change in condition. Drug doses have been intermingled with fake doses, temperature and humidity of the air have been subtly changed, and disparate stimuli of various sorts have been unexpectedly introduced. The supposition has been that perhaps if the subject was aware of the change he would accommodate himself to it, but that if he did not know it he could not so adjust his responses and so any change, or lack of change, in time would be the measure of the change of conditions. In this last experiment the subjects did not know that the weights were changed from day to day. When questioned after the experiment was completed they said that they could not tell, that they could not remember from one test to the other how heavy the weight had been. They had no idea of the changes of the weights and yet their results show that they tended to keep their time scores the same and to adjust the force used to the weight to be pulled.

This tendency of the subject to keep a constant time irrespective of the force required holds for subjects varying greatly as to the force used. For instance with the heaviest weights the force used varied from 10 to 27 million dynes, yet each subject tended to keep his time constant throughout. Whatever pace he set in the beginning he tried to keep. The recognition of such a motor set is not new to psychology. Müller and Schumann[2] and a number of later writers have discussed in detail the "Einstellung," or motor set; and its relation to judging of lifted weights has been elaborated by Miss Steffens.[3] Our experiment has brought out many of the same things that they have found. We have merely presented them with a different emphasis to bring out points relevant to and corroborative of our experiments with noise.

We believe that such a set is present in any test of mental or physiological work. A subject is placed in a certain situation, told to pull a weight, react to a visual exposure, or to do anything you please. If the situation is a new one he will at first be at a loss to know how fast to go, and will therefore adapt his speed to the conception of the task that he has derived from the instructions given. Different interpretations of the instructions will cause different subjects to start off at different speeds. After a short period of the work, sometimes only a few trials, they modify their imaged impression of the task and change their responses accordingly. If they thought the task was harder than it proved to be, they will decrease their speed when they learn its true nature. This is shown by the illustration cited of the man who on the first pull made a record of 100 sigma for the heaviest weight. When he found it was not as heavy as he thought it was his record fell to 370 on the second trial. If they start off too slowly they will increase. The pace toward which this adjustment tends is not in proportion to the strength of the individual, but rather toward a pace congenial to that individual, for we had several women who used more force than strong men, and the slowest record we give (subject Ke) was made by a stout man. Miss Stein[4] has made a study of the "motor automatisms" of people of different temperaments, showing that it is possible that every person has a pace congenial to him. It can not be said that if an individual is slow in a certain task he will be slow in every other, but it seems rather that in every task the subject sets his own pace. This varies also with the same task, although not as much as might seem probable; for it has been shown that learning, instead of being a process of increasing the speed of the same movements, is a substitution of more efficient movements for the older less efficient ones. It is possible to change the circumstances so much that a change in speed is almost inevitable, but in such a case the change in speed is not indicative of the *amount* of change in the situation.

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[2] Müller and Schumann, "Ueber die psychologischen Grunlagen der Vergleichung gehobener Gewichte" (Pfluger's *Arch. f. d. ges. Physiol.*, 1889, *45*, 37.

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Martin and Müller, "Zur Analyse der Unterschiedsempfindlichkeit," Leipzig, 1899.

[3] Steffens, Laura, "Ueber die motorische Einstellung," *Zeit. f. Psychol. u. Physiol. der Sinnes.*, 1900, *23*, 241–308.

It is very likely that individuals vary greatly as to the amount of opposition they present to any change in the pace set. We have some evidence of this in our figures. Suppose we take the differences in time taken by all our subjects in pulling up the heaviest weight and the lightest one, and arrange them in order from those who worked fastest to those who worked the slowest; we get the results seen in Table XXVIII.

If we group the above into three groups of five subjects each, eliminating one subject (Ja) who made slower time with the light weight than with the heavy, we find that the fastest group has an average difference of 34.9 sigma, the middle group an average difference of 45.4 sigma, and the slowest group 29.4 sigma. These figures however cannot be taken at their face value for the reason that a change of one sigma at high speed amounts to more than a like change at low speed. If we take the average time for each group and find the acceleration that a change in one sigma would make at this speed we find that for the fastest group a change of one sigma requires a change of acceleration of 40 cm. per second, one sigma change in the middle group a change of acceleration of 27 cm. per second, and in the slow group a change of acceleration of 13 cm. per second is required for one sigma change in time.

Since with the fastest group a change of acceleration of 40 cm. is required for every sigma change in time, an average change in time of 34.9 sigma would denote an average change in acceleration

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[4] *Loc. cit.*

TABLE XXVIII

SHOWING DIFFERENCES IN TIME BETWEEN THE HEAVIEST AND LIGHTEST WEIGHTS

Subject	Heaviest Weight, Sigma	Lightest Weight, Sigma	Difference	Average Differences for Three Groups
Gy	170.3	144.5	25.8	
Wi	171.4	136.4	35.0	
Pn	187.5	139.2	48.3	34.9
Bn	188.3	163.0	25.3	
Hn	195.7	155.6	40.1	
Li	203.8	154.3	49.5	
Vg	208.3	156.8	51.5	
Sr	209.9	162.8	47.1	45.4
Is	214.4	165.7	48.7	
Bh	221.1	190.8	30.3	
Ja	223.9	240.2	−16.3	
Sl	226.6	202.9	23.7	
Kd	234.4	190.9	43.5	
Mg	241.7	212.7	29.0	29.4
Si	247.6	206.7	40.9	
Ke	329.1	319.4	9.7	

for this group of 1,396 cm. In the middle group an average change in time of 45.4 sigma denotes an average change in acceleration of 1,226 cm.; while in the slowest group an average change in time of 29.4 sigma denotes an average change in acceleration of 382 cm. Since under similar conditions a change of acceleration is proportional to a change in force, evidently a person who sets a very slow pace maintains the greatest uniformity in speed regardless of conditions, doing it however with the least change in the output of energy. One who sets a very fast pace is not quite so uniform in speed when conditions are changed, but he changes his force most in trying to be uniform. One who sets a middle pace is most variable in speed, and is between the slow and fast subject in his efforts toward uniformity.

One might suppose that if a subject is urged to do his utmost in a test, that when the conditions were made more difficult, he would be less able to meet the change than one who worked more slowly; the supposition being that he would be nearer his maximum speed. Although the above calculations show that in response to changed conditions those who work the fastest do vary more than the slowest in time, they only vary 14 per cent. more, while they show a 272 per cent. greater variation in force. The slow worker is more easily influenced by his conditions than a fast worker although he may show it less. A fast pace does not mean that the worker is near his limit but that he is fired up to the work in hand, and that he will offer greater opposition to resistance than one who is not roused enough to work hard.

Summary.—In an experiment in which the space factor was constant and the time and energy could both be accurately measured, it was found that:

1. While changes in the work to be done caused corresponding changes in time, the time changes were no criterion upon which to calculate the changes in amount of work.
2. The general tendency is for a subject to keep his time score constant irrespective of the force required.
3. The force varies much more significantly than the time with changes in the task.
4. The "motor set" is therefore a time set rather than an energy set.
5. The greatest opposition to a change in pace is offered by those who set the fastest pace. One who sets a slow pace keeps the most uniform time but with the least opposition. One who sets a medium pace varies most in speed, and occupies a middle position in his efforts toward uniformity.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

THE first experimental studies in psychology were concerned very largely with time measurements. Reaction time and the speed of mental processes occupied most of the horizon for some time. Later the measurement of association time, the time required to perform a new motor act, learning time, the relation of time to memory processes, and the successful measurement of other cerebral processes in their time relations has broadened the scope and brightened the outlook for experimental psychology. At first the end of such investigations was to formulate the laws of mental life, and in this direction great success has been achieved. Compared with the recency of the attempts, no less remarkable has been the light that such work has thrown on individual differences. It is no wonder then, when the great cry for efficiency rang out, that psychologists should have endeavored to measure mental efficiency by utilizing the old time measurements.

In that portion of the investigation that has to do with selecting the best individuals from a group, psychology has been fairly successful, although this field is still ripe for workers. Time measurements are finely adapted to selecting the best individuals in a certain line. We want the man who can do the best work in the shortest time. While we can not say on the basis of any tests yet found who will best follow a certain occupation, yet we can select those who are fitted for the more exacting occupations of life.

When however we come to decide what conditions are conducive to the most efficient work we have met an entirely different problem. The difficulty lies in this: In measuring mental processes in order to find the laws governing their operation, or to study individuals or groups, it can be assumed that the individuals work with about the same effort; and if they do not, it makes no great difference, for in group measurements statistical treatment will take care of differences. In studying the effect of some external condition on work we must however be sure that the force exerted is a constant, or else measure any changes that it may undergo as a result of the changes in condition. To be sure if we simply wish to find out under what conditions we can get the most done regardless of cost, our problem is easy; but it is then a problem of greed and not one of efficiency.

The problem of determining the amount of energy required for any mental operation is one charged with such great difficulties that psychologists have been tempted to ignore it and to regard energy as a constant. Then on the basis of experiments resting on this assumption, they argue that there is no such thing as mental energy. Up to the present time no one has ever shown that a person does or even can keep his efforts constant during a task, and until this is proven we have no grounds for drawing conclusions from any experiment that takes for granted that it is a constant.

In the experiments which we have performed we first carried out a rigid test of the influence of noisy conditions upon the time required to do a certain task. We constructed a piece of apparatus that would enable us to escape any leak due to a faulty mechanism. We took records that would permit us to measure each response of the subject for an indefinite length of time with absolutely no intermission. In every way we tried to see to it that no conclusions could be drawn from data secured unfairly, yet as far as our time and accuracy records went we could only show that a seemingly unfavorable condition influenced the subject to a very slight extent and that after a slight retardation he exceeded the speed made under normal conditions, doing as accurate work under both conditions.

If we had been sure that the time was the only variable involved we should have rested satisfied with that conclusion no matter how paradoxical it might have seemed. We however had a little indication that the subjects struck a different attitude when they worked under noisy conditions. We therefore planned to experiment further in order to ascertain if possible in what this change consisted.

Breathing records were taken with twenty-five subjects. The comparison of the inspiration and expiration times during quiet and noisy conditions showed a constant relation. Examination seemed to show that this breathing change was due to articulation, which the subjects adopted as a means of overcoming the disturbing effect of the noises. While the changes were large in cases of noticeable articulation, in others where articulation was not noticeably present it nevertheless appeared when the breathing records were treated statistically. It may therefore well be that this factor has had something to do with the lack of correspondence between the work of different investigators on the changes of breathing due to mental processes.

The measurement of the pressure exerted upon the keys by the subjects in reacting showed that under noisy conditions the keys were struck harder than under quiet conditions, which seems to show that the subject strained harder under the noisy condition. This shows that while time and accuracy records do not suffer materially through the presence of irrelevant noises, yet there are other factors that do change as a result of this change in conditions. We do not on the basis of these experiments claim to have shown that a noisy condition is less efficient than a quiet one, but we have shown that nothing can be said as to the efficiency of any condition on the basis of time measurements alone. What time measures do show is whether or not a person is able to adapt himself to a new situation. If he is able to do so it shows the flexibility of the human organism, but it does not show anything about the condition itself.

Some critic whose eye is blinded by the intensity of practical considerations may discount the utility of what has been shown because we have not stated exactly the value of the extra force and help needed to combat the noises; but when one views the literature based on the assumption that time measures regardless of effort are a true measure of efficiency, one will be forced to admit that a question of method is in this particular case of more vital import than a numerical statement of the effects of certain noises. In the light of this investigation, when experiment shows that a person can do as much work at the end of twenty-four hours of hard work as at the beginning, that he can do just as good work under the influence of all sorts of drugs as when free from their influence, and that all sorts of distractions are unable to produce a slowing in the work of an individual; then we should conclude that a person is capable of adaptation or adjustment to all such conditions, but never from time measures alone can we derive any legitimate conclusion as to the advisability of working after long periods of labor, the influence of drugs, or the effects of distractions. Our conclusions must be conclusions regarding individual adjustment and not regarding the objective efficiency of conditions.

In all this we do not in the least mean to discount non-introspective methods of measuring the effect of external conditions. We believe that Professor Woodworth[1] was right in suggesting this method. He argued that a change in conditions should change the subject's response in some way that could be measured. We believe that this is a correct method, the mistake being simply that not all the changeable factors have been properly controlled and measured.

We tried another experiment to show more clearly the relations of time and force and their connection with adjustments to changes in conditions. It consisted in having the subject raise different weights with as much force as possible. The time was measured directly and the force computed from this measure together with the weight and the distance over which it was pulled. The results show that one tends to keep the time taken in the process constant regardless of the weight raised, and consequently to change the amount of force used in proportion to the weight. At the beginning each subject set his own pace and tended to keep that pace regardless of changes in the amount of effort required. A person does not compensate for changes in the situation by changes in the speed of the work but by changes in the effort put forth.

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[1] Woodworth, R. S., "The Accuracy of Voluntary Movement," *Psychol. Rev. Monog. Suppl.*, 1899, *3*, 25. Whole No. 13.

The need of controlling or measuring the energy factor has been felt among psychological investigators. Professor Dodge has squarely faced the problem and attempts to solve it by measuring the amount of metabolism in the neuron.[2] He states in a very clear manner the inadequacy of time measurements, and whether the measure of metabolism is the solution or not, he certainly makes it clear that something is needed besides time measurements. Thorndike[3] objects that measurements of metabolism are from their very nature isolated from measures of product yielded. He proposes instead a measure of satisfyingness. The subjects as they work are to make an introspective record of how satisfying the work is and grade it on an arbitrary scale. He has not however shown that satisfyingness or unsatisfyingness can be a measure of effort. No correlations have ever been produced that would make any such a test an adequate measure of effort. It is less capable of combination with product than would be a measure of metabolism and would be far less accurate. Of course it involves less difficulty as far as technique is concerned and that may be a consideration, but hardly a legitimate one where the facts are wanted. While we did not try to get any scale of satisfyingness in our experiments, we did, as stated in Chapter V, ask every subject how he liked the experiments and all except two said they enjoyed it. The two exceptions make slower time scores during the noises. We believe that satisfyingness would correlate higher with ability to maintain speed in accordance with the pace set by the subject than with the amount of effort required. To expend extra effort is not of itself unsatisfying. On the contrary, if it accomplishes what is desired it is very satisfying. None of the subjects found it any more satisfying to pull the light weight than the heavy one.

The need of controlling or measuring the energy factor has certainly been made clear by our experiments. We have shown that to changes of situation the subject adapts himself by changes in effort put forth. We have shown that to cause a retardation of

[2] "Mental Work, A Study of Psychodynamics," *Psychol. Rev.*, 1913, *20*, 1–42.

[3] Thorndike, E. L., "Educational Psychology," Vol. III, 1914, p. 116.

16.3 per cent. in time requires a change of 300 per cent. in the difficulty of the task. In the case of noises the time was not increased at all, was even in some cases decreased, and yet it was shown that the subject did use greater effort and had to call in the help of the organs of articulation. In the light of these findings we need to revise some conclusions as to fatigue, the effects of drugs and distractions, and other changes in the conditions under which subjects work. A change in condition may cause large changes in force before any change in time is apparent, and where such change is seen it signifies in all probability a much greater change in force.

The conclusions we have reached may be briefly summarized as follows:

A. *As to the Effect of Noises on Activity.*

1. The initial effect of noise is to retard the speed of work.
2. After this initial retardation there is an increase in speed. In many cases the subject exceeds the speed he had attained before the introduction of the noises.
3. Extra effort is put forth to overcome the noises. This is shown by an increase in the pressure exerted upon the keys in reacting. This extra effort continues pretty uniformly throughout the noisy period.
4. Articulation is used as a means of overcoming the effect of the noises. This articulation is shown by changes in the breathing of the subject. In some cases this help is not used immediately after the introduction of the noises, showing that it is an adjustment that is more deliberate than the extra expenditure of energy.
5. It is by means of these helps that the subject is able to eliminate the influence of noises from his time score and the extent of the use of these is more a measure of the effect of the noises than is the time record.

B. *As to method.*

1. Time measurements serve to indicate facts concerning the laws of mental operation, individual differences and class comparisons, but they do not serve to show whether one condition is better or worse than another.
2. In order to know whether a condition is efficient or not we must have evidence of either the constancy or change in effort. To take for granted that it is constant is to make an unwarranted assumption, and destroys the validity of any conclusions as to efficiency.
3. Tests taken without the knowledge of the subject, but

directly connected with the work in hand, give the most promise of success as indexes of change in effort expended.

C. *As to Time and Energy Relations.*

1. In a test where numerical comparisons were possible it was found that energy changes are much more significant than time changes.
2. A person tends to change the amount of energy expended to meet changing situations, and to keep the time constant regardless of variations in conditions.
3. We offer as a statement of the situation that *any real or imagined change in the resistance offered to the maintenance of a set causes a change in the output of energy.*

THE PSYCHOLOGY OF THE NEGRO

AN EXPERIMENTAL STUDY

BY

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ARCHIVES OF PSYCHOLOGY
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AUTHOR'S NOTE

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THE PSYCHOLOGY OF THE NEGRO—AN EXPERIMENTAL STUDY

CHAPTER I

REVIEW OF WORK PREVIOUSLY DONE

Interest in the psychology of the negro has produced a voluminous literature, but the knowledge to be obtained from a reading of it is not commensurately extensive. It may be not unjustly said that until what is practically the present time our information as to the negro's intellectual characteristics has been almost wholly a product of varying individual opinion and speculation. Here and there have appeared works of value, based upon study and experience and presenting carefully drawn conclusions. But for the most part the literature consists of articles which have grown out of limited and untrustworthy observation, and of articles which have attacked the problem from the standpoint of preconceived theories and have reached conclusions a priori from the premises thus held. There has been no settled body of doctrine concerning the vastly important matter of the mental capacity of the negro. One man has held that the negro is the equal of the white in intellect; another has held that a great intellectual gulf separates the two races. And there have been many varieties of views between these two extremes. There have been no facts agreed upon and consequently no reliable generalizations. Yet social practices of far-reaching importance have been based upon these varying views. Some school systems have advocated giving precisely the same training to precisely the same racial minds; other systems have advocated a differentiation of school work to meet the needs of two mentally different races; the advocates of both views have put their beliefs into practice. Many social and political considerations have of course had their bearing upon these educational matters, but certainly ideas as to the nature of the mind of the negro have not been without influence. And the social and political considerations themselves have had a psychological background.

In the last few years a number of objective studies of the intellect of the negro have been made, and they constitute a definite step toward a scientific answer to the vexed question upon which they bear. It is the purpose of the present chapter to review the experimental work which has been done in this limited field of race psychology and also some of that which has not been experimental. In the following chapters will be set forth the results of an objective study which it is hoped will contribute in some measure toward an answer to the problem.

Non-Experimental Studies

In discussing "human faculty as determined by race," Boas, in an early article ('94), the substance of which is incorporated in a later work ('11), pointed out that while the skull capacity of modern European whites is 1560 cc. and that of European whites of the neolithic period is the same, the skull capacity of the mongaloid race is 1510 cc., that of the negroes of the Pacific ocean is 1460 cc. and that of African negroes is 1405 cc. The negroes, too, were at least as tall as Europeans. Another way of putting it is to say that while 50 per cent. of whites have skull capacities of 1560 cc., only 27 per cent. of negroes equal or exceed this skull capacity. Further, "We find that the face of the negro as compared to the skull is larger than that of the American, whose face is in turn larger than that of the white. The lower portion of the face assumes larger dimensions. The aveolar arch is pushed forward and thus gains an appearance which reminds us of the higher apes. There is no denying that this feature is a most constant character of the black races and that it represents a type slightly nearer the animal than the European type." ('94,p. 311). "Our conclusion is, that there are differences between the physical characters of races which make it probable that there may be differences in faculty. No unquestionable fact, however, has been found yet which would prove beyond a doubt that it will be impossible for certain races to attain a higher civilization." ('94, p. 317).

In a later article ('01, p. 3), Boas argues as follows: "A number of anatomical facts point to the conclusion that the races of Africa, Australia and Melanasia are to a certain extent inferior to the races of Asia, America and Europe. We find that on the average the size of the brain of the negroid races is less than the size of the brain of other races, and the difference in favor of the Mongaloid and white races is so great that we are justified in assuming a certain correlation between their mental ability and the increased size of their brains. At the same time it must be borne in mind that the variability of the mongaloid and white races on the one hand, and of the negroid races on the other, is so great that only a small number, comparatively speaking, of the individuals belonging to the latter have brains smaller than any brains found among the former; and that, on the other hand, only a few individuals of the mongaloid races have brains so large that they would not occur at all among the black races. That is to say, the bulk of the two groups of races have brains of the same capacities, but individuals with heavy brains are proportionately more frequent among the mongaloid and white races than among the negroid races. Probably this difference in size of the brain is accompanied by differences in structure, although no satisfactory information on this point is available."

Boas then takes up the arguments that primitive races cannot abstract, inhibit impulses or choose according to standards of value. His contention is that primitive man does do these things, but that he does them from his own point of view and to meet his own needs, and not in the same way that civilized man does them. Similarly with the argument that while a savage can perceive well in a sensory way, he cannot interpret phenomena: he does interpret phenomena, but from his own point of view, as is the case with all men. "Our considerations make it probable that the wide differences between the manifestations of the human mind in various stages of culture may be due almost entirely to the form of individual experience, which is determined by the geographical and social environment of the individual. It would seem that, in the different races, the organization of the mind is on the whole alike, and that the varieties of mind found in different races do not exceed, perhaps not even reach, the amount of normal individual variation in each race." ('01, p. 11).

A radically different opinion from that of Boas is held by

Le Bon. ('98). This author holds that the human race may be divided into four groups on the basis of psychological characteristics: (1) Primitive races, such as the Fuegians and the aboriginal Australians, (2) Inferior races, such as the negroes, (3) Average races, such as the Chinese, Japanese, Mongolians and Semitic peoples, (4) Superior races, which are the Indo-Europeans. "No confusion is possible between the four great divisions we have just enumerated. The mental abyss that separates them is evident." ('98, p. 28). The specific differences which separate the primitive and inferior peoples from those which are higher are that the former races have a relative incapacity to reason or associate, to compare and draw conclusions, to attend, observe and reflect, to exercise foresight, to persist in a given line of activity, to hold to a distant rather than a present end. These differences are practically ineradicable, and they determine the achievement of the races. "The various elements of the civilization of a people being only the outward signs of its mental constitution, the expression of certain modes of feeling and thinking peculiar to a people, these elements cannot be transmitted unchanged to peoples of a different mental constitution: all that can be transmitted is the exterior, superficial, and unimportant forms." ('98, p. 233).

Races of men also differ in the relative size of their brains, according to Le Bon. From measurements of the volume of several thousand skulls, he concludes that the differences are real, though not very considerable. And he further draws the interesting conclusion that the more civilized races display a much greater divergence from their average brain size than do the races which are backward. Thus the higher races have more very large and very small brains than primitive people, relatively to their average; the brains of the inferior races conform more nearly to their average type.

Tylor writes ('04, pp. 74-75): "There seems to be in mankind inbred temperament and inbred capacity of mind. .... In measuring the minds of the lower races, a good test is how far their children are able to take a civilized education. The account generally given by European teachers who have had the children of lower races in their schools is that, though they often learn as well as the white children up to about twelve years old, they then fall off, and are left behind by the children of the ruling race. This fits with what anatomy teaches of the less developed brain in the Australian and African than in the European. It agrees also with what the history of civilization teaches, that up to a certain point savages and barbarians are like what our ancestors were and our peasants still are, but from this common level the superior intellect of the progressive races has raised their nations to heights of culture."

"Moreover, there is this plain difference between low and high races of men, that the dull-minded barbarian has not power of thought enough to come up to the civilized man's best moral standard. .... Much of the wrong-doing of the world comes from want of imagination. .... The lower races of men are so wanting in foresight to resist passion and temptation, that the moral balance of a tribe easily goes wrong, while they are rough and wantonly cruel through want of intelligent sympathy with the sufferings of others, much as children are cruel to animals through not being able to imagine what the creatures feel." ('04, pp. 407-408).

In discussing racial brain differences Tylor says: "Professor Flower gives as a mean estimate of the contents of skulls, Australian, seventy-nine; African, eighty-five; European, ninety-one. Eminent anatomists also think that the brain of the European is somewhat more complex in its convolutions than the brain of a Negro or Hottentot. Thus, though these observations are far from perfect, they show a connection between a more full and intricate system of brain-cells and fibres, and a higher intellectual power, in the races which have risen in the scale of civilization.

"It is often possible to tell by inspection of a skull what race it belongs to. The narrow cranium of the negro would not be mistaken for the broad cranium of the Samoyed. .... Taking the diameter from back to front as 100, the cross-diameter gives the so-called index of breadth, which is about 70 in the Negro, 80 in the European, and 85 in the Samoyed. ....The Australian and African are *prognathous* or "forward jawed,' while the European is *orthognathous*, or 'upright-jawed.' At the same time the Australian and African have more retreating foreheads than the European, to the disadvantage of the frontal lobes of their brain as compared with ours." ('04, pp. 60-62).

G. Stanley Hall's view of the relative mental make-up of the negro and the white may be set forth in the following quotations: "No two races in history, taken as a whole, differ so much in their traits, both physical and psychic, as the Caucasian and the African. The color of the skin and the crookedness of the hair are only the outward signs of many far deeper differences, including cranial and thoracic capacity, proportions of body, nervous system, glands and secretions, vita sexualis, food, temperament, disposition, character, longevity, instincts, customs, emotional traits and diseases. All these differences, as they are coming to be better understood, are seen to be so great as to qualify if not imperil every inference from one race to another, whether theoretical or practical, so that what is true and good for one is often false and bad for the other." ('05, p. 358).

"Another racial trait of the negro is found in the sphere of sexual development. Special studies show that the negro child up to about twelve is quite as bright as the white child; but when this instinct develops it is earlier, more sudden, and far more likely permanently to retard mental and moral growth than in the white who shoots ahead. Thus the virtues and defects of the negro through life remain largely those of puberty." ('05, p. 362).

This last contention of Hall's, that the negro's development comes to what is at least a partial stand-still at puberty, occurs in the writings of others who have dealt with the subject. Tylor has already been quoted on this point. The idea is that after puberty the individual's mental life broadens and takes on new aspects: abstraction, a tendency to penetrate into the meanings of things, the power to perceive relations, and the ability to appreciate logical, aesthetic and moral situations. Before adolescence a child's activities are mainly the so-called lower mental processes, such as perception, memory and the motor responses. The negro, being the lower type, fails to attain the post-pubertal traits to the degree that the white child attains them, and therefore remains permanently on a lower level. But on this level, and in the traits which constitute it, he is fully the equal of the white child. Thus, while he cannot reach the finer elements of mental attainment, the negro is yet the equal or the superior of the white in sense capacity, rote memory, objective attentiveness, motor control, and qualities of a similar nature. Another statement from Hall bears upon this: "Mental development after puberty is much more uncertain than before. The first twelve years of life represent larger and more fundamental qualities. Adolescence adds a new story, less stable, very liable to arrest at any stage. .... This makes nearly the whole post-pubic period critical, peculiarly exposed to dangers from without, because it is so plastic and susceptible, and still more so because the growth forces that push youth on toward maturity are so liable to show signs of exhaustion before their work is finished. Hence it follows that length of the growing period is one of the most important factors in development. Lower races often stop short when sexual maturity is achieved." ('03, p. 811.) In this connection, Libby ('08), reporting the result of an experiment in which he had white high school and grammar grade pupils write compositions descriptive of a certain sentimental picture, states that the feeling, meaning and sentiment of the picture were grasped only by pupils older than fourteen years. And Ellison, as reported by Bagley ('09), says that children below the age of thirteen do not have abstract ideas such as would enable them to give good definitions.

Odum ('10, pp. 36-37) agrees with the general idea represented in the last two quotations from Hall: "Negro children are easily interested, attentive, eager and alert. For the most part they are bright and learn easily. In many cases they appear brighter than white children of the same age. They learn from memory easily and retain little things for some length of time. .... They learn readily to do things by imitation and become comparatively skilful in a short time. .... However, there are many negro children who have an almost total lack of mental perception, whose minds are so dense that they can scarcely learn anything. The percentage of such cases increases with age." This author makes many statements, without, however, giving evidence to substantiate them, to the effect that the negro child, as shown by experiments, is brightest—i. e., most able to do and learn simple things—at thirteen years of age, and that he is of greatest ability—i. e., most able to "grasp and hold that which confronts the mind"—at eight or nine years of age; that the negro's mental development practically ceases at the age of about thirteen; that there is an almost entire absence of sexual morality among the great body of negroes, children and adults, due to the predominance of their "physical impulses and pleasure-pain feelings;" that the more primal emotions, fear, anger, jealousy, self-exaltation, self-depreciation, sorrow, etc., are especially active in the negro; that dynamically the negro is volatile, easily responsive to stimuli, guided by present impulses, unrestrained—in short, that his life is one of temporary emotion rather than of permanent sentiment.

A recent article by Bardin ('13) argues that there must be a connection between racial mental differences and the physical differences between races, since both were evolved together. And since it is becoming increasingly evident that the negro and the white differ mentally, we must therefore suppose that there are corresponding neural differences, as marked, in their way, as are the external physical signs of race, such as skin, hair texture and facial angle. From this position the writer contends that in attempting to modify the negro's mind while yet keeping him a physical negro we are undertaking the impossible. "It follows, therefore, that present ideals in regard to the solution of our Negro problem .... are biologically fallacious, and impossible of attainment. We can never make the Negro like the white man mentally. We can never have a bi-racial state based upon an identity of ideas and political philosophies in both races." ('13, p. 374). This contention is almost identical with that quoted above from Le Bon.

One of the most interesting estimates of the intelligence of the negro was made by Francis Galton ('92). In a study of the relative capacity of the white and negro races he divided each race into sixteen defined grades of ability, eight above and eight below its racial average, and considered that the intervals separating the grades were equal throughout. After a survey of eminent men of each race he came to the conclusion that the ablest negro ranked two grades below the ablest white. Then, by an application of the "law of deviation from an average," he held that negroes as a race have two degrees of ability less than Europeans. Another way of expressing it is to say that the difference between negroes and whites in intellectual capacity is about one-eighth of the difference between the most eminent man and the lowest idiot. Galton then goes on to point out that the experiences of travelers among native tribes and the prevalence among negroes of feeble intellects furnish confirmation of his estimate.

After a survey of the available evidence of racial mental differences, Thorndike ('10, pp. 67-68) sums up as follows:

"From all these facts each student may make his own estimate of the original mental differences of races, and learn at least the need of more actual measurements of race differences and of intelligence in interpreting them. My own estimate is that greater differences will be found in the case of the so-called 'higher' traits, such as the capacity to associate and to analyze, thinking with parts or elements, and originality, than in the case of the sensory and sensori-motor traits, but that there will still be very great overlapping. Calling the difference between the original capacity of the lowest congenital idiot and that of the average modern European 100, I should expect the average deviation of one pure race from another in original capacity to be below 10 and above 1, and the difference between the central tendencies of the most and the least gifted races to be below 50 and above 10. I should consider 3 and 25 as reasonable guesses for the two differences."

Experimental Studies

From these studies and opinions of a non-experimental nature we may turn to those which are based upon quantitative investigation. The first attempt at a quantitative study of the negro with which the writer is familiar is that by Bache, published in 1895. This investigator starts with the assumption that the more inferior the race, the quicker the reaction time. "That the negro is, in the truest sense, a race inferior to that of the white can be proved by many facts, and among them by the quickness of his automatic movements as compared with those of the white." ('95, p. 481). The results of the tests on twelve whites, eleven Indians and ten negroes showed the whites to be the slowest and the Indians to be the quickest with auditory, visual and electrical stimulation. The speed of the negroes was roughly midway between that of the Indians and the whites. The writer explains that the reason the negroes were slower than the Indians was that they were of mixed white and negro blood and had inherited the effects of slavery, while the Indians' mode of life compelled them to rely upon quick movement. This explanation is offered to strengthen the writer's contention that the Indian is a higher race than the negro, and consequently should have a slower reaction time. The study is hardly conclusive; the numbers tested were too small, and the variabilities of the average reaction times are not given. Certainly the initial assumption was not proved by the tests.

Smith made some association and memory tests upon a "typical" negro boy sixteen years of age. The nature of the tests is not given, nor are the results set forth. The author's general conclusion, plainly unwarranted on the basis of the work done, is as follows: "The negro child is psychologically different from the white child. In automatic power he is superior, but in the power of abstraction, of judgment and analysis he is decidedly inferior. This fact must be recognized in the school training." ('96, p. 60).

Stetson ('97) gave a memory test to five hundred white and five hundred colored children in the fourth and fifth grades of the schools of Washington, D. C. The average age of the white children was 11 years; the average age of the colored children was 12.57 years. The test was somewhat crude. It consisted in reading to the children four verses of four lines each, explanations of the verses being given and the class repeating them twice in concert. Later the verses were reproduced orally to the experimenter by each child, and the reproductions were scored as being 100, 75, 50, or 25 per cent. correct. The results showed that the negroes were superior to the whites in memory of three of the verses, while the whites were superior in memory of one. The average score for the four verses was: Whites, 58.09; Colored, 58.27. In other words, there was practically no difference in memory capacity between the two races. But in school studies the average rank of the white children was 74.32, while the average rank of the colored was 64.73. This superiority of the whites in school work led the author to conclude that the negroes were deficient in reasoning power, since the test showed that they were not deficient in memory. This conclusion, of course, is subject to criticism on the ground that a number of other factors may have been responsible for the academic inferiority of the colored children.

McDonald studied 91 colored children by means of physical and mental tests. His conclusions are summarized as follows: "Among the boys and girls the per cent. of long heads is much greater after puberty than before. This is also true of white boys but not of white girls. The colored boys are more sensitive to heat and locality after puberty than before. The reverse is true with the white boys, but the colored girls, like the white girls, are less sensitive after puberty. .... Colored children are much more sensitive to heat than white children. .... Colored girls have larger circumference of head at all ages than white girls. .... White children, relatively to their height, are longer bodied than colored children. The percentage of long-headedness among colored boys is more than double that of white boys." ('99, pp. 1141-1143). The writer states that from a table based on teachers' estimates of the brightness, dullness and mediocrity of colored children, (number indefinite), it appears that the percentage of bright children, both boys and girls, increases rapidly between the ages of seven and eight, and continues to increase slightly until the age of thirteen. From thirteen to sixteen the percentage of bright pupils decreases rapidly. It would seem that the results of this work should be verified by other investigators before being accepted. The chances for error in the mental tests used are considerable, and the composition of the various groups tested is not quite clear.

The foregoing experimental studies, all of which were made prior to 1900, emphasize the need of a careful technique in the quantitative handling of this question. The opportunities for error are very great, and in inexperienced hands psychological tests and statistical methods may lead to results that are worse than useless. A field as little worked and as inviting as this of the comparative psychology of the white and the negro is likely to attract, and has attracted, investigators who lack the necessary training—just as it has attracted theorists who were not adequately grounded in the essentials of their work. One would not be far wrong in saying that all of the experimental work done on the psychology of the negro prior to 1900 is of practically negative value.

In summarizing the status of scientific race psychology in 1910, Woodworth writes as follows:* "One thing the psychologist can assert with no fear of error. Starting from the various mental processes which are recognized in his textbooks, he can assert that each of these processes is within the capabilities of every group of mankind. .... Statements to the contrary, denying to the savage powers of reasoning, or abstraction, or inhibition, or foresight, can be dismissed at once. If the savage differs in these respects from the civilized man, the difference is one of degree, and consistent with overlapping of savage and civilized individuals." ('10, pp. 3-4).

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*The work reviewed by Woodworth was that by himself, Bruner, Ranke, Rivers, McDougall and Myers. This work had to do almost exclusively with the sense capacities of primitive groups, and the summary by Woodworth makes it unnecessary to give a further account of it here.

Woodworth then goes on to discuss the evidence in regard to the several sense capacities. Natives of Brazil, the steppe-dwelling Kalmucks, Papuans, Indians, Filipinos and other races have been tested for visual acuity, and found, on the whole, to have vision superior to that of the average white, but the overlapping between the whites and these races is great. "We may perhaps conclude that eyesight is a function which varies somewhat in efficiency with difference of race, though with much overlapping. .... It did not seem possible, however, to assert anything like a correspondence between eyesight and the degree of primitiveness or backwardness of a people. .... Even if small differences do exist, it is fairly certain that the wonderful feats of distant vision ascribed to savages are due to practice in interpreting slight indications of familiar objects." ('10, pp. 5-6). In the case of hearing, the tests indicate that whites are superior to primitive peoples. This superiority may be due in part to the fact that the ears of civilized man are better protected from injuries than are those of savages, and that the meatus is kept cleaner by the white man. Then, too, the white is more familiar with the sorts of sound used in the tests than is the savage, and on this account may detect them more readily. The few tests that have been made for keenness of smell show no higher acuity among negroes and Papuans than among Europeans. In ability to discriminate two points on the skin the evidence is conflicting; on the whole there is probably no appreciable superiority in favor of any of the races tested. The experiments which have been made to determine the acuity of the pain sense are largely vitiated by the fact that savages and civilized men have different standards as to what constitutes pain. "On the whole," says Woodworth, "the keenness of the senses seems to be about on a par in the various races of mankind." ('10, p. 7). In reaction time, speed of tapping and susceptibility to illusions, the tests seem to indicate that the different races are about equal.

In discussing tests for intelligence as opposed to sensory and motor capacity, the writer points out that the form-board is the only test of intelligence which has been used with different races. "This test was tried on representatives of several races, and considerable differences appeared. As between whites, Indians, Eskimos, Ainus, Filipinos and Singhalese, the average differences were small, and much overlapping occurred. As between these groups, however, and the Igorot and Negrito from the Philippines and a few reputed Pygmies from the Congo, the average differences were great and the overlapping was small. Another rather similar test for intelligence which was tried on some of these groups, gave them the same relative rank. The results of the test agreed closely with the general impression left on the minds of the experimenters by considerable association with the people tested. And, finally, the relative size of the cranium, as indicated, roughly, by the product of its three external dimensions, agreed closely in these groups with their appearance in intelligence and with their standing in the form test. If the results could be taken at their face value, they would indicate differences of intelligence between races, giving such groups as the Pygmy and Negrito a low station as compared with most of mankind." ('10, pp. 10-11).

One of the important investigations of the mental capacity of the negro is that by **Mayo ('13)**, who studied the school marks of 150 white and 150 colored high school pupils in the schools of New York City. His results can best be given in his own words: "To summarize, the following are the leading results deduced from the data considered:

"The median age of white pupils at the time of entering high school in the city of New York is 14 years 6 months; of colored pupils 15 years 1 month—a difference of 7 months. The average deviation for whites is 9 months; for colored, 15 months. Twenty-seven per cent. of the whites are as old as the median age of the colored or older.

"Colored pupils remain in school a greater length of time than do the whites. For the cases studied, the average time spent in high school for white pupils was 3.8 terms; for colored, 4.5 terms. About 28 per cent. of the whites attain the average time of attendance for the colored.

"Considering the entire scholastic record, the median mark of the 150 white pupils is 66; of the 150 colored pupils 62; a difference of 4 per cent. The average deviation of white pupils is 7; of the colored 6.5. Twenty-nine per cent. of the colored pupils reach or surpass the median mark of whites.

"The white pupils have a higher average standing in all subjects. .... The percentage of colored pupils reaching the median mark of the whites in the several subjects is as follows: Modern languages, 33; mathematics, 32; history, 31; the sciences, 29; Latin and Greek, 27; English, 24; the commercial subjects, 22; and all subjects together, 29.

"The total number of subjects pursued by the white group was 2433; the total number of subjects passed on the first trial was 1855; the percentage of subjects passed being 76. The total number of subjects pursued by the colored group was 2382; the total number of subjects passed on first trial was 1379, the percentage of subjects passed being 58. Interpreting these figures as a measure of relative scholastic efficiency, the efficiency of colored subjects is 76 per cent. of that of the whites; that is, the colored pupils are about ¾ as efficient as the whites in the pursuit of high school studies." ('13, pp. 44-45).

These results are significant as they stand, and they become still more so when it is considered that the colored pupils studied were, as Mayo points out, a more closely selected group than the whites. How much more closely the negroes were selected than the whites is not known. It must also be borne in mind that the colored group was not made up of persons of pure negro blood. The percentage of mulattoes is not stated, but it is probably high. And the presence of mulattoes considerably raises the standard of negro attainment, as will be shown in a later chapter. Another consideration tending to emphasize the racial differences found by Mayo is that the colored pupils with whom he dealt were for the most part either emigrants from the South or the children of emigrants, and that they therefore probably inherited the ability and energy which leads the ambitious negro to seek to better his condition in the North. On the other hand, it is difficult to estimate the white group represented in this study. It contained English, Germans, Irish, Italians and Jews in indefinite numbers, but a random selection of whites was carefully observed, and the group is probably typical of the white high school population of New York.

Phillips ('12), in a study of retardation in the public elementary schools of Philadelphia, found percentages of retardation as follows in schools attended entirely by colored pupils: 68.2, 60.6, 67.3, 70.9, 66.3, 72.8, 58.2, 59.3. The percentages of retardation in the respective school districts in which these eight schools were situated were as follows: 41.8, 44.5, 45.1, 45.1, 37.2, 36.0, 36.0, 33.3. In other words, the percentage of retardation in the colored schools ranged from 72.8 to 58.2, while the percentage of retardation in the districts which contained these schools ranged from 45.1 to 33.3. The average percentage of retardation for the city as a whole was 40.3. Each of the colored schools had a greater percentage of retardation than any of the white schools, even those composed almost entirely of foreigners, and in those schools attended by both white and colored pupils the percentage of retardation on the whole varied directly with the percentage of colored pupils in attendance. The writer concludes by saying: "It is a question whether the course of study is suited to the negroes, as the educational results are so far behind those in the other schools, and it is very doubtful whether even a liberal interpretation of the course of study would meet the educational necessities of this group." ('12, p. 90).

In a later article ('14), Phillips reports the results of an attempt to ascertain the causes of this retardation by means of an application of the Binet tests to white and colored children of the same chronological age and home conditions, the tests being made in all cases by the same individual. "Forty colored girls and 46 colored boys, totaling 86, were tested by the Binet scale; 75 white girls and 62 white boys, totaling 137, were likewise tested. The home of each of these 223 pupils was visited and the home conditions noted, as Excellent, Good, Fair and Poor. In so rating the home, the material (money), intellectual, and moral elements were noted in making up the rating. In the following comparison only the white children of excellent home conditions are compared with the colored children of excellent home conditions; the white of good home conditions with the colored of good home conditions, and so on. This method of procedure, of course, necessitated the elimination of quite a number of those tested, so that our final comparison was made on 29 each of colored boys and girls respectively." ('14, p. 191).

The results are stated as follows: ".... we see that of those tested 37.9 per cent. of the white boys were retarded, while 65.5 per cent. of the colored boys were retarded; that 46.4 per cent. of the white girls were retarded and 71.4 per cent. of the colored girls were retarded; and that 42.1 per cent.

of the white boys and girls combined were retarded, and that 68.4 per cent. of the colored boys and girls combined were retarded. This makes the colored boys retarded 17.4 (27.6)* per cent. more than the white boys; the colored girls retarded 25 per cent. more than the white girls; while the total rate of retardation of both groups is 26.3 per cent.

".... we find that 31 per cent. of the colored girls (boys)† are accelerated while 62 per cent. of the white girls (boys)† are accelerated; that 28.5 of the colored boys (girls)† are accelerated and 53.5 per cent. of the white boys (girls) ;† and that 29.8 per cent. of colored boys and girls are accelerated and 57.8 per cent. of both white girls and boys. This makes a difference in the acceleration between the two races of 31 per cent. in favor of the white boys, 25 per cent. in favor of the white girls, 28 per cent. in favor of the white pupils with boys and girls combined.

"This would seem to corroborate the findings in the case of pedagogic retardation. We see in every group, considering the retardation from pedagogical or psychological viewpoints, that the colored pupils are retarded from 20 to 30 per cent. more than the white pupils, and that the white pupils are always greatly above them in acceleration." ('14, pp. 191-195).

It is interesting to note that the total number of pupils tested, including those eliminated on account of not having comparable home conditions, gives practically the same comparative result as was obtained from the picked group. The percentage of retarded pupils in the total colored group was 54.6; the percentage of retarded pupils in the total white group was 24. The percentage of accelerated pupils in the total colored group was 6.9; in the total white group it was 20.4.

The author concludes as follows: "In applying the Binet tests to colored children the following facts of interest were fortunately thrust upon our attention. In the first place the colored pupils as a class were good in the memory tests and poor in those requiring judgment. They were generally slower in response. The testing of the colored children took a much longer time than the white. Their reaction time was greater, they were less animated. It is significant to note that the younger white children were more advanced than the colored children of the same age. This is in contradiction to the generally accepted fact that colored children are quicker when young.

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*This figure should evidently be 27.6 instead of 17.4. It represents the difference between the percentages of retardation of white and colored boys, which are 65.5 and 37.9, as quoted, and also as given in the tables which accompany the article.

†Phillips seems to have made an error here. In order to make the figures agree with the tables from which they are taken, and also with the differences in acceleration as quoted, the words "boys" and "girls" should be interchanged as indicated by the brackets.

"If the Binet tests are at all a gauge of mentality it must follow that there is a difference in mentality between the colored and the white children, and this raises the question: Should the two groups be instructed under the same curriculum?" ('14, p. 196).

The first application of the Binet tests to whites and negroes was made by Strong, and was reported by her ('13) and by Morse ('14). Two hundred and twenty-five white and 125 colored children were tested in the schools of Columbia, S. C. The percentage of children testing more than one year below age was 10.2 for the white and 29.4 for the colored. The percentage testing more than one year above age was 5.3 for the white and 0.8 for the colored. The largest group of white children was that testing at age; the largest group of colored children was that testing one year below age.

An attempt was made to divide the white children into "city children" and "mill children," in order to arrive at a conclusion as to how far inferiority in the tests was due to poor environment. The environment of the mill children is of considerably lower grade than that of the city children, and is not markedly different from that of the negroes. When this division was made the results showed that 6 per cent. of the city children were more than one year below age while 18 per cent. of the mill children were more than one year backward. On the face of it, then, this would indicate that the comparatively poor showing made by the negroes was in large measure due to poor home conditions. But in fact it leaves the question still open. For while mill children may have adverse environment, they may also have poor native capacity due to their poor heredity. Their unfavorable surroundings may be the product of a lack of inheritable capacity in their parents.

This criticism applies to all attempts to determine the influence of environment upon people whose heredity is not known to be alike. And yet such efforts are made with seemingly increasing frequency. It should be remembered that poor achievement, in psychological tests or in any other activity, may be accompanied by inferior social condition and yet not be the product of that condition. The achievement and the condition may both result from one and same cause, lack of native capacity. In such matters as are sought by all, such as the ordinary facilities of life and intercourse according to the prevailing standards, it is very probable that native capacity determines the relative attainment of men within any large and homogeneous unit of mankind. And it is very probable that the presence of poor home environment among any considerable group of our population is due to a comparative absence of ability in that group as a whole. This absence is inherited by the offspring of that group. Errors due to a neglect of this consideration need to be especially guarded against in psychological investigations which aim to study environmental influence.

Strong divided the negroes tested by her into classes on the basis of degree of skin pigmentation. She says: "The children were divided into three groups according to color. This classification was not a scientific one, and the statement of results may be entirely worthless. There were 34 dark children, 35 medium in color, and 43 light colored in this classification, 122 in all. Of the dark colored, 14.4 per cent. tested below age, 76.7 per cent. tested at age, and 8.8 above age. Of the next group, somewhat lighter in color, 31.1 per cent. tested below age, 62.2 at age, and 6.6 per cent. above age. Of the lightest group 44.2 tested below age, 44.2 at age, and 11.6 above age. The darkest children are more nearly normal, the lightest show the greatest variation, both above and below normal." ('13, p. 506).

Morse comments upon the tests as follows: "In general it may be said that the colored children excel in rote memory, e.g., in counting, repeating digits (but not one was able to repeat 26 syllables), naming words, making rhymes and in time orientation. They are inferior to the whites, however, in aesthetic judgment, observation, reasoning, motor control, logical memory, use of words, resistance to suggestion and in orientation or adjustment to the institutions and complexities of civilized society." ('14, p. 78). With reference to pedagogical retardation, he writes: ".... according to the Binet scale, a larger number of white children are in a school grade below their mental ability than above, whereas the reverse is true of the colored children." ('14, p. 78).

In reviewing this study, Bruner says: "The tables show another interesting point on which the author makes no comment. At the ages of six, seven and eight just about twice as many negro children as white rate below age, whereas for the ages of ten, eleven and twelve the superiority of the whites over the negroes is but slight. This suggests that the rate of maturing may be more rapid with the negro children, so as to make them older, mentally, at the age of twelve than white children of the same age." ('14, p. 385).

A study of the learning capacity of whites and negroes was made by Baldwin ('13). A somewhat elaborate substitution test was used five minutes a day for sixteen days with 37 white and 30 colored delinquent adolescent girls. Their ages ranged from 13 to 21 years. "Fourteen other negro girls were too feeble mentally to perform the tests after the initial instructions although they worked assiduously for the period of three weeks, and three white girls failed to do 50 per cent. of the work correctly." ('13, p. 317). From the summary of the results: "In this type of learning it is found that: 1. Comparing the amount of work done by the thirty-seven white girls with the work done by the thirty negroes who accomplished more than 50 per cent. of correct results, it is evident that the negroes are decidedly inferior. The white girls made 72.3 substitutions as a general average, the negroes 55.8. The negroes accomplished 62.4 per cent. as much work as the white girls and made 245.3 per cent. as many errors. Practically all the superior negroes in the school were included in the test.

"2. The learning capacity of delinquent negro girls differs quantitatively and qualitatively from that of the white girls, and the educational corollary follows that different methods of instruction and training are required for the negro girls than for the white girls." ('13, pp. 331-332).

On the whole the inferiority of the negroes was about the same in both absolute amount of work done and in learning capacity. The negroes as compared with the whites were slow to warm up, quick to lose interest, difficult to stimulate except through flattery, irregular, moody, vacillating in attention, inaccurate, envious of each other's progress, given to mumbling, grumbling, humming, saying funny things while at work.

A study of this kind is difficult to evaluate in its bearing upon normal subjects. The girls were all committed to an institution as delinquents, and their mental ability was probably considerably below the average. Whether both races were equally below the average is not known. The fact that fourteen negro girls could not work the test at all, while only three white girls failed to complete as much as 50 per cent. of the work, would indicate that the negroes were farther below the average racial ability than were the whites; but this is not conclusive. That the test failed to enlist the interest of the colored girls indicates that their true learning ability was not measured. But this, too, is of doubtful significance, since the very fact that the negroes were not interested as were the whites possibly points to a deficiency in the colored group. On the whole, it seems safe to say that the test is probably indicative of a true racial difference, though the amount of such difference is left uncertain.

Since the tests to be described in the following chapters were made, there has appeared a preliminary report by Pyle ('15) of an extensive investigation of the relative mental capacity of whites and negroes. This investigator tested 408 colored pupils, from eight to sixteen years of age, inclusive, in the public schools of Columbia, Mexico and Moberly, three towns in Missouri, using a number of standard tests, and compared the results thus obtained with the norms which he had previously ascertained for white children in the same tests. As the report which has so far appeared is only preliminary, it is impossible to go into detail concerning the work done, but the author's words may be quoted to indicate the main outlines of this valuable research:

"The following are the conclusions to which the work so far points. .... In general the marks indicating the mental ability of the negro are about two-thirds those of the whites. The negro girls approach the white girls in ability a little more closely than the negro boys approach white boys. Negro boys and girls are farther apart in ability than are white boys and girls. In both races the girls are superior, if the average performance is taken as the basis of comparison. With increasing age, there is a tendency for the difference between whites and negroes to become less. This tendency is more marked with boys than with girls. About one-fifth of the negroes are equal or superior to the average of the whites, while three-fourths of the whites are equal or superior to the average of the negroes. In the same school grade, the negroes are several months older than the whites. Negro girls have the best permanent memory for ideas in the eleventh year. The same is true of white girls. Negro boys have the best permanent memory for ideas in the twelfth year and white boys in the thirteenth year. In rote memory the negroes have a much better memory for concrete than for abstract words, but are greatly inferior to whites in both.

"If, for purpose of comparison, the negroes are separated into two groups according to social position, it is found that the negro boys of better social class have about four-fifths of the ability of white boys. The negro girls of better social position have an ability which is about three-fourths that of white girls. Difference in social position has less effect on negro girls than on negro boys. The difference in social position has most effect on tests requiring quickness in learning, quickness in controlled association, in immediate and permanent logical memory and in constructive imagination as measured by the Ebbinghaus test. With negro children of the better social class the tendency to approach the norm of white children is more marked. In the substitution, controlled association and Ebbinghaus tests, the negroes are less than half as good as whites. In free association and the ink-blot tests they are nearly as good. In quickness of perception and discrimination and in reaction, the negroes equal or excel the whites.

"At all ages, the physical development both in muscular strength and muscular speed is nearly the same for negro boys and white boys. The same is true for negro girls and white girls until the age of ten. After ten, negro girls are stronger than white girls, but white girls are faster. The negro girls are stronger probably because they do more muscular work than white girls do. Muscular speed seems to be little affected by conditions of life while muscular strength is much affected by them.

"Perhaps the most important question that arises in connection with the results of these mental tests is this: How far is ability to pass them dependent upon environmental conditions? Our tests show certain specific differences between negroes and whites. What these differences would have been had the negroes been subject to the same environmental influences as had the whites, it is difficult to say. The results obtained by separating the negroes into two social groups would lead one to think that the conditions of life under which the negroes live might account for the lower mentality of the negroes. On the other hand, it may be that the negroes living under the better social conditions are of better stock. They may have more white blood in them." ('15, pp. 357-360).

Neurological Studies

It is assumed everywhere as a matter of course that mental differences imply neural differences. If there are mental differences between two races, then we may expect to find differences in the nature of the brain structure of the two races, and vice versa. The comment is frequently made that apparent differences in the size or shape of the brains of given racial groups must indicate corresponding psychical divergencies. Such comment has been quoted in some of the foregoing abstracts, notably in those from Boas, Le Bon and Tylor. If there is a racial, or individual, inheritance of mind there must be an inheritance of appropriate anatomy and physiology.

A few recent investigators have attacked this problem of racial neural differences. In Baltimore, Bean studied the brains of 103 negroes and 49 Caucasians. He concludes that, "Not only is the anterior association center smaller in the Negro than in the Caucasian, but the whole frontal lobe of the Negro is smaller." ('06, p. 374). The negro stands in an intermediate position between man and ourang in the relative size of his frontal to his parietal and occipital lobes.

Bean then goes on to point out that this conclusion is in accord with well-known traits of the negro. He states, citing Flechsig as authority, that the anterior association center, which is comparatively small in the negro, is intimately connected with ideas regarding personality; the relations of self, subjectively and objectively; the capacity for ethical and aesthetic judgment; self-control, especially in such matters as sexual excitement, anger or vexation; will power. The posterior association center, on the other hand, which is comparatively large in the negro, is more intimately connected with the special senses; it is objective and concrete, while the anterior center is subjective and abstract in the mental processes which its operation accompanies. "The relative differences found in the association centers of the two races is suggestive in relation to the known characteristics of the two, in view of Flechsig's work. The Caucasian is subjective, the Negro objective. The Caucasian .... is dominant and domineering, and possessed primarily with determination, will-power, self-control, self-government, and all the attributes of the subjective self, with a high development of the ethical and aesthetic faculties. The Negro is in direct contrast by reason of a certain lack of these powers, and a great development of the objective qualities. The negro is primarily affectionate, immensely emotional, then sensual and under stimulation passionate. There is love of ostentation, of outward show, of approbation; there is love of music, and capacity for melodious articulation; there is undeveloped artistic power and taste — Negroes make good artisans, handicraftsmen — and there is instability of character incident to lack of self-control, especially in connection with the sexual relations; and there is lack of *orientation*, or recognition of position and condition of self and environment, evidenced by a peculiar bumptiousness, so-called, that is particularly noticeable. One would naturally expect some such character for the Negro, because the whole posterior part of the brain is large, and the whole anterior portion small, this being especially true in regard to the anterior and posterior association centers." ('06, pp. 378-379).

Further, Bean reports that he found the ratio of the corpus callosum to the total brain weight to be greater in the Caucasian than in the negro, the anterior end of the corpus callosum in the whites being relatively large when compared with its posterior end.

In weight, the 51 negro brains, male, averaged 1292 grams, while the 37 white male brains averaged 1341 grams; the 28 female negro brains averaged 1108 grams, while the 9 white female brains averaged 1103 grams. The negroes were of a higher class than the whites, however, and mulattoes were included among them.

These conclusions of Bean's are very interesting, but they seem to need further confirmation before they can be accepted as final. Following Bean, Mall ('09) found no such definite racial differences. He states that the brain weight of eminent men is 100 grams above that of men in general, and that the average white man has a brain 100 grams heavier than that of the average negro. But the frontal lobe as compared with the rest of the brain has the same relative weight in both negroes and whites, male and female. And the configuration of negro and white brains is the same. ". . . . with the present crude methods the statement that the negro brain approaches the foetal or simian brain more than does the white is entirely unwarranted." ('09, p. 20). "It certainly would be important if it could be shown that the complexity of the gyri and sulci of the brain varied with the intelligence of the individual, that of the genius being most complex, but the facts do not bear this out, and such statements are only misleading. . . . . brains rich in gyri and sulci, of the Gauss type, are by no means rare in the American negro." ('09, p. 24).

This investigator reviews the previous work done in this field, and comes to the final conclusion that there is no valid evidence to show significant brain differences from the point of view of race, sex or genius.

Karl Pearson ('07), after a study of the heads of 1000 Cambridge graduates and 5000 school children, states that his results corroborate the conclusions of previous articles, and sets forth his findings as follows: "The average correlation between head length or head breadth and intelligence is .11. . . . . no sensible modification is made in this result if allowance be made for either weight or stature." But "some 44 per cent. of very able men have heads smaller than the average slow man and some 44 per cent. of slow men heads larger than the average specially able man. This order of numerical relationship holds for the whole range of the characters dealt with, and in view of it we see how idle it is to assert that head measurements can be of any service in the prediction of intelligence. . . . . Differences in size of head will not account for at most 1/12, and probably not as much as 1/20, of the observed differences of capacity whether between adults or between children." ('07, p. 121).

Hrdlicka ('98) investigated the physical differences between 1100 white and 300 negro children, and found that the negro's forehead is narrower but not lower than that of whites, and that the negro's head is unusually long and narrow, while the heads of whites are of all shapes. He says the negroes' ears are smaller, their arms, hands and feet longer, and their chest somewhat deeper than is the case among white children. The weight of white children at all ages is somewhat greater than that of negroes, but the negroes at all ages and of both sexes are three or four pounds stronger with each hand.

Hrdlicka also finds, as did Le Bon in the abstract previously given, that the variation among the whites is greater than among the negroes. "The white children show more *diversity*, the negro children more *uniformity* in their normal physical characters. This fact becomes gradually more marked as we advance with the age of the children." ('98, p. 476).

It is impossible to make an adequate summary of the views set forth in this chapter; the abstracts given are themselves summaries. But it is clear that by far the greater number of writers who have dealt with the problem of the relative mental ability of the white and the negro take the view that the negro is inferior. This is particularly true of those investigators who have used quantitative methods. The negro has not shown the same capacity as the white when put to the test of psychological or educational experiment, and the racial differences revealed have been considerable. In the higher mental processes that go to make up the capacities necessary to a successful conduct of civilized life, the negro seems to fall short to a far greater degree than in the elementary traits which man has in common with the lower animals. In sense capacity, in instinct, in motor ability, there is no evidence that he inferior to the white man. It is in such matters as reasoning ability, the power to perceive relations, to exercise creative imagination, to subordinate a present passion to a distant end, that the weight of evidence and opinion indicates his relative deficiency.

With regard to the comparative equality of white and negro children up to the age of adolescence and the then ensuing superiority of the whites, the evidence is not at all clear. The theories as to the significance of adolescence upon which this view is based, have themselves undergone restricting modification in very recent years, and the whole matter is at present unsettled. There may be greater differences between white and negro children either before or after adolescence, so far as is known. Or adolescence may have no appreciable bearing upon ascertainable racial differences.

The question of differences in brain structure between the two races is likewise subject to controversy. It seems to be indubitable that in brain size there is a difference, but the internal structure of the brain, which is far more significant for intelligence than size, is as yet a subject for debate rather than for evidence in so far as it concerns differences between whites and negroes.

The abstracts given are believed to include all of the experimental studies and a fair sampling of the better studies which are not experimental. It is probably true that there are more people who believe in racial mental equality than the reviews would indicate; equality is taken for granted, as in the greater part of our school system and in our political life; it is those who believe in racial inequality who consider their views novel enough for publication. It may be said that the main conclusion one may draw from a study of the literature bearing upon the mental side of our race question is that we have taken a step toward its solution, but that the problem is still a problem.

The evidence with regard to the relative ability of pure negroes and mulattoes will be discussed in Chapter IV, as will that bearing upon racial variability.

CHAPTER II

THE SUBJECTS AND THE TESTS

The Subjects

The experiments to be described herein were made in December, 1914, upon pupils in the schools of Richmond, Fredericksburg and Newport News, Virginia. According to the Census for 1910 ('10), Richmond has a population of 127,628, of whom 36 per cent. are negroes; Fredericksburg has a population of 5874, of whom 25 per cent. are negroes; and Newport News has a population of 20,205, of whom 36 per cent. are negroes. In the State as a whole, 32.6 per cent. of the population are negroes. The white inhabitants of these cities are to a very large extent native born and of native parentage; in the state as a whole 95.4 per cent. of the white population is native born and of native parentage, and in these cities the percentage does not considerably differ from that of the state.

The Census shows that in Richmond 1.2 per cent. of the native white population ten years of age and over are illiterate, while 19.6 per cent. of the negroes are illiterate. In Fredericksburg the corresponding percentage of white illiteracy is 1.5; that of negroes is 20. In Newport News the percentages are: whites, .6; negroes, 12. In the state as a whole, 8 per cent. of the white population and 30 per cent. of the colored population are illiterate. It is thus evident that the cities have a smaller percentage of illiteracy, both white and colored, than the state, and that a much greater proportion of the negroes than of the whites is illiterate.

The percentages of the population 6-14 years of age that attend school are as follows, according to the Census: Richmond—native whites, 79.2 per cent.; negroes, 65.2 per cent. Fredericksburg—whites, 76 per cent.; negroes, 64 per cent. Newport News—whites, 76; negroes, 69 per cent. In the state as a whole 73.2 per cent. of the white and 58.7 per cent. of the colored population 6-14 years of age attend school. It thus appears that a somewhat larger percentage of whites than of negroes attend school, and that this difference between white and colored school attendance is only slightly less in the cities than in the state at large. It should be noted that there is no compulsory education law in any of the cities mentioned, and that only an inconsiderable fraction of the population of the state attend school under such a law.

So far as these figures show, the white and colored populations of the cities in which the tests were made do not differ significantly from the general white and colored populations of Virginia. The negroes, in the cities and in the state at large, attend school less than do the whites in proportion to their numbers and are considerably more illiterate.

This last consideration, that the whites attend school in larger proportion than the negroes, and that the negroes are more illiterate, indicates that on the whole the negroes who do attend school are a more closely selected group than are the whites who attend school. It is a rarer occurrence for a negro to become educated. The school selects for its operations a more circumscribed group of negro than of white children. The Richmond School Report for 1912-'13 ('14) strengthens this conclusion.

The figures in the report show that of the total white school enrollment, 10.53 per cent. are in the high school; of the total colored school enrollment, 4.97 per cent. are in the high school. That is, that out of an equal number of pupils from each race, there are twice as many white as colored of high school grade. If we compare the percentage of the total school population, white and colored, enrolled in elementary and in high schools, we arrive at the same result. Of the white and colored school populations, there are 54 and 55 per cent., respectively, enrolled in the elementary schools; but there are 7.5 per cent. of the white and only 3.1 per cent. of the colored school population enrolled in the high schools. The same percentage of the white and of the colored school populations is enrolled in elementary schools, but there is twice as great a percentage of the white as of the colored enrolled in high schools. Of the colored population as a whole, a smaller proportion is in school as compared with the whites; and of those in school, a smaller proportion is in high school. It is a rarer thing for a colored than for a white child to attend school at all; it is a much rarer thing for a colored school child to be in high school. Colored high school pupils are the "chosen few" of their race to a greater extent than are white high school pupils.

The nature of the selective factors which thus act more intensively upon negroes than upon whites as the school grades advance is difficult to ascertain. Among the causes of elimination from school are such matters as poor health, poverty, mental or moral deficiency, lack of ambition or energy. It would seem that these forces, in the long run, must select for survival in the school system those who by reason of their own capacity, as represented in themselves and in the inheritable traits which prompt and enable their parents to send them to school, are best fitted to make progress in academic work. It would seem that the school must select as well as train those who have greatest ability and who thus profit most by school attendance. That this is true in the case of the high school's selection of negro pupils is especially indicated by the following considerations.

The figures for retardation in the schools of Richmond are as follows: In the white elementary schools, 51.8 per cent. of the pupils are above the normal age for their grade; in the colored elementary schools, 75.0 per cent. of the pupils are above the normal age for their grade. While in the white high school 52.1 per cent. of the pupils are above the normal age for their grade, and in the colored high school, 55.8 per cent. of the pupils are above normal age. The colored elementary pupils are 23.2 per cent. more retarded than are the white elementary pupils; the colored high school pupils are only 3.7 per cent. more retarded than are the white pupils of their grade. It is evident that the pupils who do not accomplish what is expected of their age drop out of the negro schools before high school is reached to a greater extent than out of the white schools. Indeed, while it appears from the figures that the colored pupils who are eliminated from the school system are those who do not perform the work of their age, it does not appear that this is true of the whites. It would almost seem that whereas the negro goes to high school by reason of his ability and determination, the white goes on account of some other incentive, such as, perhaps, social pressure or the custom of his class. It is not unreasonable to conclude on the basis of the figures for retardation that one of the selective factors which operate to a greater extent upon colored than upon white pupils is inability to do the school work expected of their age. In this connection it should be recalled that Phillips, in a study reviewed in Chapter I, found the relative percentages of white and colored retardation in the elementary schools of Philadelphia to be about the same as those found here; and that his investigations with the Binet tests showed that the greater pedagogical retardation of the colored pupils was paralleled by their greater psychological retardation.

When we divide the elementary school into primary and grammar grades, we find that 35 per cent. of the white elementary pupils are in the grammar grades, while only 21 per cent. of the colored elementary pupils are in these grades. This is in confirmation of our conclusion that the higher grades have a larger percentage of the white than of the colored children. But when we divide the high school into two parts, consisting of the first and second and the third and fourth years, respectively, we find a different situation. Twenty-five per cent. of the white high school pupils are in the third and fourth years combined, while 28 per cent. of the colored high school pupils are in the third and fourth years combined. Here we have a larger proportion of colored than of white pupils in the upper years. It is interesting to note that Mayo, in a quotation previously given, found the same situation in the high schools of New York. The colored pupils studied by him remained in school longer than did the white pupils. It seems that after the high school is reached, selective factors eliminate a larger percentage of white pupils than of colored.

This tends to corroborate the view expressed above, that the negro who enters high school does so because of his ability and determination, whereas the white high school pupil often enters by reason of social pressure, custom, or the tradition of his race. There is a marked difference between the work of the high school and that of the elementary school. One of the problems of modern education is to lessen the gap between the two. Within either school the work of a given grade is not much more difficult than the work of the grade below it. But the first year of the high school is much more difficult than the last year of the elementary school. This increased difficulty causes a large number of the less capable pupils to drop out of high school at the end of the first or second year. A larger proportion of white than of colored pupils so drop out because a greater proportion of white than of colored entered without serious purpose or the requisite ability. The negroes who enter high school are a more closely selected group, and they therefore more nearly finish the course. The figures show that the percentage of retardation in the colored high school is the same for the first two years and for the last two years; in the white high school there is a considerably greater percentage of retardation in the first two years than in the last two.

Another fact which bears upon the relative action of selective factors upon white and colored children in the public schools is that a much larger proportion of white than of colored pupils of high school grade are not enrolled in the public schools at all, but attend private institutions. This is particularly true in Richmond; and on the whole the pupils who attend private schools are of better social standing, and therefore, on the whole, probably of greater ability, than the average of the school population. The public high school thus loses a number of pupils of ability, and this loss is not felt by the colored high school as it is by the white.

Taken all together, the facts brought out show that the colored child in the schools of Richmond, in the upper grades and especially in the high school, is much more closely selected by reason of his ability than is the white child. We should therefore expect the colored pupils of advanced grade to attain a higher score in psychological tests than those of lower grade, when compared with white pupils. This we shall find to be true. And we shall also find, in marked confirmation of the present contention, that colored high school pupils excel colored elementary pupils to a much greater extent than white high school pupils excel those of lower grades. Phillips, Strong and Pyle, (see Chapter I), found the mental difference between whites and negroes to become less as the grades advance. The explanation of their findings is probably to be found in this matter of selection. It seems likely that if one could test a random and not an educational selection of whites and negroes, he would not find the difference between the races to decrease with age. And it appears to be certain that racial mental differences discovered by means of tests upon school children are in reality smaller than the actual differences between the races.

The detailed figures for the school systems of Fredericksburg and Newport News are not available, but there is no reason for believing they would point to a different conclusion from that found in Richmond. The Richmond figures are much more reliable than those of the other two cities would be since they are based upon a far greater number of pupils. It may be said that the Richmond figures are derived from the records of 12,018 white and 6184 colored children.

The number of pupils tested in these experiments was as follows: In Richmond, 269 white and 319 colored; in Fredericksburg, 84 white and 63 colored; in Newport News, 133 white and 39 colored. In all, there were 486 white and 421 colored pupils—a total of 907. The Richmond pupils were in the three years* of the grammar school and the four years of the high school; in the grammar grades there were 149 white and 175 colored; in the high school there were 120 white and 144 colored. The Fredericksburg pupils were: white, 36 in the 6A and 7A grades and 48 in the high school; colored, 28 in the 6A and 7A grades and 35 in the high school. In Newport News all of the pupils tested were in the grammar grades: 133 white, in grades 6B, 7A and 7B; and 39 colored in grades 6A and 7A. Throughout the study main reliance will be placed upon the results obtained from Richmond, on account of the greater number of pupils tested there; the results from Fredericksburg and Newport News will be used as corroborative. It may be remarked that in all ways the only difference between the results from the three cities is that those obtained from Fredericksburg and Newport News emphasize the racial differences found to a somewhat greater degree than do those from Richmond.

The high schools tested in Richmond were the John Marshall, white, and the Armstrong, colored. These are the only high schools in Richmond. In the John Marshall High School there are* 1394 pupils, 535 boys and 859 girls; in the Armstrong High School there are 76 boys and 257 girls, a total of 333. The elementary schools tested were the Madison, white, and the George Mason, colored. These were chosen because in the opinion of the school authorities their pupils were fairly typical of the average white and colored populations of the city. The Madison School has 871 pupils, 398 boys and 473 girls; the George Mason School has 849 pupils, 360 boys and 489 girls. All four schools are parts of the public school system.

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*The elementary school in Virginia covers only seven years. The first four years are the primary, the last three are the grammar. The grammar grades are 5A, 5B, 6A, 6B, 7A, 7B. In the high school there are four years, and the grades are 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B. "A" means the first half of a year; "B" means the second half of a year.

In Fredericksburg, the white pupils tested were in attendance upon the one public school building for whites in the city. The colored elementary pupils were in the colored public school. But the colored high school pupils were in a private school conducted by colored people, since the city does not maintain a colored high school. This private school conforms closely in all essential respects to the requirements for public high schools, and its pupils may be fairly compared with those in the public schools.

In Newport News, the white pupils were in the John W. Daniel School and the colored pupils were in the John Marshall School. These schools were typical of the schools for the two races, in the opinion of the school authorities. No high school pupils were tested in Newport News, since there is no colored high school.

In selecting the pupils from the various schools for the tests, in some instances the only grade of a given degree of advancement in the school was tested; in other instances, where choice had to be made among several grades of a given degree of advancement, the school authorities selected a grade of average ability; in still other instances, where it was necessary to test only part of a given grade, the selection of pupils was made by taking them in alphabetical order from the roll. By these means it is believed that the selection of pupils for the tests was made a fair one in all of the schools.

That the schools themselves were comparable as between the two races there is no valid reason to doubt. All of them pursued the same general course of study; within a given city all were parts of the same system, with the exception of the colored high school in Fredericksburg. The teachers and principals of the colored schools were colored in Fredericksburg and Newport News. In Richmond, the colored elementary school had colored teachers and a white supervising principal; the colored high school had white teachers throughout. No difference could be perceived in the attitude of the two races toward the tests: both white and colored seemed to enjoy the work rather than the reverse, and both worked with vigor.

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*These are the figures for 1912-'13. The present figures are not available, but they do not differ significantly from those given.

The number of pupils tested is set forth in detail in Tables 1 and 2. In the treatment of results, no account is taken of a record from only one pupil, and the two lowest and the two highest ages are disregarded on account of the small number of pupils in them.

TABLE I.

NUMBER OF SUBJECTS TESTED—CLASSIFIED BY AGE AND SEX

Ages	9	10	11	12	13	14	15	16	17	18	19	20	21	Totals
Richmond.														
White Boys	1	1	12	15	20	31	17	11	18	5	..	..	..	131
White Girls	..	..	11	18	21	27	18	16	20	5	2	..	..	138
Col. Boys	..	1	6	14	19	18	16	14	9	6	4	..	..	107
Col. Girls	..	3	9	22	34	42	27	33	23	15	3	..	1	212
Fredericksburg.														
White Boys	..	..	3	2	7	11	7	6	6	3	..	..	..	45
White Girls	..	..	1	6	6	7	6	6	5	2	..	..	..	39
Col. Boys	..	..	1	3	2	1	3	5	1	2	4	..	..	22
Col. Girls	..	..	1	..	9	10	3	2	10	2	2	1	1	63
Newport News.														
White Boys	..	..	3	15	20	12	5	..	..	..	..	..	..	55
White Girls	..	..	5	18	25	23	4	2	..	..	..	..	..	77
Col. Boys	..	..	1	2	..	4	1	..	..	..	..	..	..	8
Col. Girls	..	..	..	7	6	12	3	3	..	..	..	..	..	31

TABLE II.

NUMBER OF SUBJECTS TESTED—CLASSIFIED BY GRADES

Grades	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A	Totals
Richmond.												
White	38	35	19	21	18	18	30	29	..	35	26	269
Colored	42	38	35	22	19	19	42	31	21	25	25	319
Fredericksburg.												
White	..	..	20	..	16	..	14	12	..	11	11	84
Colored	..	..	21	..	7	..	10	9	..	8	8	63
Newport News.												
White	..	..	..	59	40	34	..	..	..	..	..	133
Colored	..	..	23	..	16	..	..	..	..	..	..	39

A fact should be noted in comparing the results from the white and the colored high schools of Richmond. The white pupils in each of the four years tested were in the first, or "A", half of the year's work. The colored pupils, however, on account of the way they are classified in the school, were in both the first and the second, the "A" and the "B", halves of each of the four years work. To state it in another way, the white high school pupils were in grades 1A, 2A, 3A and 4A; while the colored high school pupils with whom they are compared were in grades 1A and 1B, 2A and 2B, 3A and 3B, and 4A and 4B. Thus the colored pupils were farther advanced academically than were the white pupils in each of the four years. For the sake of simplicity the high school grades for both white and colored are put down as "A" grades in the tables. But this is somewhat unfair to the white pupils, since the colored were in both "A" and "B" grades in about equal numbers.

The ages of the grades tested are shown in Table 3, and the difference in ages between the two races is shown in Table 4. The colored pupils are older, grade for grade. In Richmond, the difference is .36 of a year, in Fredericksburg it is 1.02 years, and in Newport News it is 1.7 years. The difference as shown for Richmond should be reduced somewhat on account of the fact that the colored high school pupils are in reality more advanced in grade than the tables would indicate, as was pointed out in the preceding paragraph. Stetson,

TABLE III.

AGES OF THE GRADES TESTED

Grades	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
Richmond.											
White Av.	12.4	12.5	13.4	13.2	13.3	13.6	14.4	15.4	..	16.5	17.0
A.D.	1.1	1.1	1.4	.9	1.0	.9	.9	1.1	..	.8	.5
Col. Av.	12.3	12.8	12.7	13.5	14.0	14.5	14.9	16.2	16.5	16.8	17.6
A.D.	1.0	.9	.8	1.0	.9	.8	.7	.8	1.0	.7	1.1
Fredericksburg.											
White Av.	..	..	12.5	..	13.6	..	14.4	15.6	..	16.2	16.9
A.D.	..	..	.9	..	.9	..	.8	1.0	..	.7	.5
Col. Av.	..	..	13.2	..	14.0	..	15.4	17.2	..	17.3	18.2
A.D.	..	..	1.0	..	.9	..	1.6	1.0	..	.9	1.2
Newport News.											
White Av.	..	..	..	12.8	12.6	13.6	..	..	..	..	..
A.D.	..	..	..	1.0	.8	.6	..	..	..	..	..
Col. Av.	..	..	13.0	..	14.3	..	..	..	..	..	..
A.D.	..	..	1.0	..	.8	..	..	..	..	..	..

TABLE IV.

AGES—DIFFERENCE IN YEARS BETWEEN THE WHITE AND THE COLORED SUBJECTS TESTED

(Minus signs indicate that the colored subjects are of greater age.)

Grs.	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Richmond.	.1	—.3	.7	—.3	—.7	—.9	— .5	— .8	— .3	— .6	— .36	.09
Fredericksburg.	..	..	—.7	..	—.4	..	—1.0	—1.6	—1.1	—1.3	—1.02	.11
Newport News.	..	..	..	..	—1.7	..	..	..	..	..	—1.7	..

Mayo, Phillips and Pyle, (see Chapter I), also found that the colored children tested by them were appreciably older than white children of the same school grade, and this is indicated by school censuses in general, (see Mayo, '13).

This age difference is significant as showing that colored pupils are less advanced than white pupils in school work. But it is not important in a comparison of the standing of the two races in mental tests, if the comparison is made by both age and grade. When the scores are compared by ages, the white pupils in the comparison will be of higher school grade; when they are compared by grades, the colored pupils will be of greater age. In the former case any possible advantage will be on the side of the whites; in the latter case it will be on the side of the colored pupils. If success in the tests is not dependent upon school training, it is obvious that an age comparison is the better. But if success in the tests does depend upon school training, a comparison by grades is to be preferred. Where the influence of school training upon standing in the tests is unknown, a comparison by both age and grade would seem to be advisable. In this monograph the results in all of the tests are set forth by both ages and grades, but evidence will be brought forth to show that ability to perform the tests is not appreciably dependent upon school training, and consequently the age comparisons are the more reliable. A comparison by ages, indeed, is to be preferred to one by grades in all serious investigations of racial mental differences. For a grade is essentially a group of people selected because they are much alike in capacity. And a mental test which is dependent upon academic training must be comparatively worthless as an index of true racial ability.

The Tests

The tests employed in this investigation were selected primarily with a view to ascertaining racial differences in the higher rather than in the lower intellectual capacities. It is in the higher capacities that men are supposed to differ most. And it is these capacities that are of greatest influence in determining their relative achievement. The investigations previously made and the views previously held indicate that there are no considerable group differences in sensation, in motor control, in native retentiveness. The differences to which evidence has pointed have been, on the side of intellect as opposed to feeling, in such abilities as those included under the terms constructive imagination, the apprehension of meaning, reasoning power. These latter traits divide mankind into the able and the mediocre, the brilliant and the dull, and they determine the progress of civilization more directly than do the simple and fundamental powers which man has in common with the lower animals. While testing these traits, it was thought advisable at the same time to employ certain tests of lower capacity for the sake of comparison.

The tests used were the Woodworth and Wells Mixed Relations, I and II; a form of the Ebbinghaus Completion Test; a Cancellation Test; and one of the Columbia Maze Tests. A test of immediate memory was also given, but the results from it were discarded. In this test the series of digits to be remembered were presented orally by the experimenter, and some of the pupils, both white and colored, undoubtedly wrote down the numbers surreptitiously as they were called, instead of waiting until after the series were finished. It is interesting to note that evidence of this occurs more frequently in the results from the lower than from the higher grades, and more frequently in the colored than in the white schools. A possible "study of dishonesty" is suggested.

The mixed relations test, in its various forms, has been used by a number of investigators, and has been highly recommended as a test of intelligence. Wyatt ('14), in a study undertaken in order to determine reliable intelligence tests, found correlations of .80 and .62 between the mixed relations test and careful subjective estimates of intelligence, in two groups of subjects. He also found a correlation of .85 between the mixed relations and completion tests, and states that these two tests correlate more highly with intelligence than do any of the thirteen other tests employed by him, and that they also correlate more highly with the other tests as a whole. Vickers and Wyatt ('13) attempted to determine suitable tests for assigning children to school grades, and found the mixed relations, completion and hard opposites to be most satisfactory. The correlations between the mixed relations test and intelligence, (intelligence being defined as adaptability to new conditions), were .51, .61, .64 and .86 with four different classes of children. The reliability of the test, as measured by its correlation in repeated trials, was high, the average correlation between the trials being .70. Burt ('11) found a correlation of .52 with intelligence, and a coefficient of reliability of .92. He recommends the test, along with the completion test, as being an excellent indication of ability in logical inference or reasoning.

The particular form of the test as used is the one designed and standardized by Woodworth and Wells ('11), its originators. It consists of two parts, numbered I and II, and is in reality two separate tests. The parts are of equal difficulty and the twenty relations in each part differ as little in difficulty as it was possible to make them. The test is printed in full in the appendix, as are the others used in this investigation.

It is always difficult to state just what mental function is experimented upon by a given test. The various traits so overlap and are so dependent upon one another in their action that no one trait can be completely isolated. If a test correlates well with other tests of the same or related performances, it may be taken as a reliable index of ability in the functions involved, although the specific functions themselves cannot be definitely and exhaustively described. Most tests are so regarded. But within limits it is possible to state approximately the functions that are tested. The mixed relations test is primarily one of controlled association of the sort that is the basis of all efficient reasoning. It demands that a relation be perceived and applied; and then that another and a different relation be perceived and applied, and so on through the test. A simple test of controlled association, such as the opposites test, requires that a mental set or determining tendency be previously formed at the instance of the experimenter, and then applied unchanged to stimuli as they occur. The mixed relations test goes further than this, and requires that the mental set itself be determined by the subject before it is applied, and that a different mental set be fixed for each stimulus. It involves what James ('92) has called "sagacity", and requires association by similarity, the perception of meaning, voluntary control of ideas. Woodworth and Wells state that the test measures skill in handling associates by means of a determining tendency; mental alertness and flexibility; that it is a "logical relations" test. It is safe to say that the functions involved are those most intimately concerned in that successful handling of material which distinguishes the intelligent and mentally active individual from the unintelligent and dull. The language factor is of course present, but where the words used are simple and well known, this is not important in a test of individual or group differences. (See Simpson, '12, p. 69ff.).

The completion test was invented by Ebbinghaus ('97), and has been widely used. Wyatt ('14), as mentioned above, recommends the test as one of intelligence; he finds correlations of .85 and .61 with subjectively estimated intelligence in two classes of school pupils. Vickers and Wyatt ('13) found correlations of .82, .88, .76 and .82 with intelligence in four groups of subjects. And they found correlations of reliability of .84, .87, .66 and .69 in successive trials with the four groups. Burt ('11), using two forms of the test, found correlations with intelligence of .48 and .53. Brown ('11) states that the test correlated .43 and .69 with general intelligence in two groups of subjects. Simpson ('12) found a correlation of .92 for reliability. Correlations between the completion and a number of other tests used by him were: hard opposites, .92; easy opposites, .75; memory of words, .92; memory of passages, .91; cancellation, .68; adding, .71; geometrical forms, .54; learning pairs, .72; completing words, .50; drawing lengths, .26; estimating lengths, .52. A correlation of .67 between the completion test and the average of nine other varieites of association tests was reported by Whitley ('11).

The form of completion test herein used is composed of the twenty-five separate sentences which constitute sentences 23 to 47, inclusive, of a completion test designed by Mr. M. R.

Trabue*, of Columbia University. These sentences are graduated in difficulty, and have been standardized by Trabue in experiments upon several thousand school children. Numbers 23 to 47 were selected because they were well adapted in difficulty for use with the school grades to be tested. A completion test in the form of separate sentences has several advantages over one in paragraph form, such as has generally been used. Where a paragraph is employed, accidental factors are much more likely to influence the result. The subject of the paragraph may be relatively unfamiliar to any given pupil; or one unusually difficult part of the whole may render the completion of a large section of the rest unduly difficult. This cannot occur where there are a number of separate sentences dealing with different subjects and each counting as a unit. Then, too, in scoring it is probably better to score on the basis of sentences than of words. Thought proceeds by judgments, whole sentences, not by words. And in a test of thought power rather than of language power one should be able to gauge the apprehension of meaning as a whole rather than what is perhaps the more distinctively literary ability required to fit a word into a specific context. It is thought, not its vehicle, that it is to be measured. The ability to use language must probably remain a factor in this test, though not the most important factor where the material is familiar. Thought and language are largely implications of each other, and in great measure ability in one means ability in the other. But as far as possible the language factor should be elminated and the thought factor emphasized.

The mental functions measured by the completion test are akin to those involved in the mixed relations test. This is indicated by the high correlation between the two. Ebbinghaus ('97) described it as essentially a test of intelligence, requiring the ability to combine separate impressions into a coherent whole. Simpson ('12) calls it a test of selective thinking. Whitley ('11) classes it among her association experiments. It would seem that the ability to perceive relations, to apprehend meaning, to control association in order to fill a gap, is implied in a successful performance of the test. Association or selective thinking or intelligence are perhaps equally good terms to apply to the processes. In the language

*Since the above was written a preliminary account, (Trabue, '15), of this test has been published.

of popular speech, the test requires "good sense" and a "quick mind".

The maze test employed is the so-called straight maze designed and used at Columbia University. This has been found (see Whitley, '11) to be the most satisfactory form of maze test. It is comparatively easy to score, and the eye strain resulting from its use is negligible as compared with certain other forms of maze. A correlation of .49 was found by Whitley between the straight and the average of three other varieties of the test. Simpson ('12), using a scroll maze, found a coefficient of reliability of .76 for the test and a coefficient of correlation of .26 with the average of twelve tests of intellectual functions.

The traits measured are quickness and accuracy of movement in drawing a line between the two sides of the maze without touching them—motor as opposed to intellectual abilities.

The concellation test is the familiar "A Test", designed by Cattell and Farrand ('96). It is a regulated pied text, and contains one hundred A's and sixteen of each of the other letters—five hundred capital letters in all. The test has been used by many investigators and in a variety of forms, such as the "A—T" test, the "E—R" test, etc.; and it has been described as a test of various functions. Pillsbury ('08) says it is one of the best tests of degree of attention. Whipple ('10) agrees that this is one of its main features. Bourdon ('95) used it to measure discriminative ability. Judd ('07) similarly classes it as a test of discriminative reaction. Cattell and Farrand ('96) regarded it as a test of rate of perception. Thorndike ('04) also used it as a test of perception. Pyle ('13) gives it as a test of perception and attention. On the whole, it seems that the test measures all of these capacities as they function together. To cancel A's it is necessary to perceive them discrimnatively and attentively, and to react by the simple cancelling movement. The correlations of the test with other tests and with class standing are generally small and sometimes negative. (See Whipple, '10).

In giving the tests, the instructions to the subjects were by means of examples on a blackboard, supplemented by such oral directions as were necessary. A constant order of succession was maintained among the tests. The maze was given first, while the pencils were sharp, then followed cancellation, mixed relations I, mixed relations II, and completion. This order was invariable except in Newport News, where, on account of a lack of time, the mixed relations and completion tests were given first, to make sure that they, as the most important, would be finished. The schools were taken as wholes, one after another, and the lower grades were generally tested before the higher. There was no appreciable chance for aid in working the tests to be transmitted in conversation from grade to grade.

The time-limit method was used, and the effort was made to allow just enough time in each test to enable to quickest of all the subjects to finish. In Fredericksburg, where the tests were given first, the time allowed for the mixed relations test was 15 sec. longer than elsewhere, and the time allowed for the completion test was 30 sec. longer. The time was reduced in the other cities because several of the Fredericksburg subjects finished the work before the time limit was reached. This extra time in Fredericksburg had apparently no effect upon the relative standing of the white and colored groups, but it is obvious that if the time allowed is longer than is necessary for the quickest subjects to complete the test, the group differences will be somewhat reduced. The brightest of the pupils will not be able to accomplish as large an amount of work as their ability warrants. On the whole, the time limits as used were approximately the periods required by the ablest of the subjects. With the exception mentioned, these times were as follows, for all grades: each mixed relations test, 1 min., 45 sec.; completion test, 8 min., 30 sec.; maze test, 1 min., 30 sec.; cancellation test, 1 min., 20 sec. The subjects were told that they would have barely time to finish if they worked at their highest speed. In all of the tests the directions were to try for as great speed as possible, while not making any mistakes. If an unusually difficult part of the test should be met, in the mixed relations and completion tests, they were advised to pass it by without a too great waste of time. A stop-watch was used, and all directions were given by the writer, who also did all of the scoring.

In scoring the mixed relations test, each accurate relation recorded was graded 2; each partially correct relation was graded 1; each error was graded 0, as was each omission. The possible maximum score was thus 40 for each of the two parts in which the test was given. The scoring was, of course, absolutely uniform throughout, for each type of correct, partially correct or incorrect record.

The completion test was scored in the same way. Each correct sentence was rated 2; each partially correct sentence was rated 1; and each incorrect or omitted sentence was rated 0. Since there were twenty-five sentences, the possible maximum score was 50.

The maze test measured two things, speed and accuracy. Accuracy was scored by counting the number of touches made. Speed was determined by the amount of the test completed or the distance traversed. In rating this, each straight section of the maze was counted 1. Since there are 140 straight sections in the test, the possible maximum score for speed was 140.

This test presents a difficulty in its scoring. The two quantities which it measures are variables which do not maintain a constant ratio to each other. If only a short distance is traversed within the time limit, the number of touches is small as compared with the amount done. But if a great distance is traversed, the number of touches is large as compared with the space gone over. To illustrate: a distance of 60 will mean, say, 4 touches, a ratio of 1 to 15; but a distance of 120 will mean, say, 20 touches, a ratio of 1 to 6. And yet the latter record may be as good as the former. As speed increases, accuracy normally decreases, and in a constantly changing ratio.

In handling the maze test, a number of investigators have chosen to deduct a certain arbitrary amount from the speed record for each touch. Thus Whitley ('11) and Simpson ('12), using the amount-limit method, add 5 sec. and 10 sec., respectively, for each touch made. But this cannot be satisfactory. A touch made by a subject who works at great speed is far less significant than a touch made by a subject who works at a much lower speed. Where the ratio of accuracy to speed is a variable one, as in this case, no constant figure can be deducted from the speed record for each error.

What is needed is a set of ratios, expressing the relation of touches to distance at each of a large number of possible distances. Such a set of ratios could be ascertained by adequate experiment, and they would be very interesting in themselves and also very useful, since there is no other practicable group test of motor capacity. But at present they do not exist, and it is therefore impossible to give the best treatment to the results of the maze test.

The method that is followed herein is to set forth the number of touches and the distance covered by each group of subjects. The comparison of group with group must then be based on the relative number of touches made and the relative distance traversed. If the score for either touches or distance, or both, should be the same for each group, an accurate comparison would of course be possible. Or if one group should exceed the other in touches but not in distance, or in distance but not in touches, an accurate comparison could be made. It generally happens, however, that one group exceeds the other in both touches and distance, and in this case the difficulty arises. The ratio of touches to distance is normally smaller in a slow group than in a fast one, and smaller to an unknown degree.

The cancellation test also measures both speed and accuracy, but here the difficulty in equating the two is not so pronounced. The score for speed is obtained by counting the number of A's cancelled; the score for accuracy is arrived at by counting the number of A's omitted in the amount of text gone over.

The number of A's omitted is very small, and is constantly so from group to group. Roughly, only about one-third or one-half of the subjects make any omissions at all. And it does not appear that there is any very definite relation between the number of omissions and the number of cancellations. Several investigators have reported this to be true of the test. Woodworth and Wells ('11) say there are no workable individual differences in accuracy and that there is little reason for its being scored. Binet ('03) found that subjects worked with approximately equal accuracy. Others, as Thorndike ('04), ignore omissions in giving results from the test. Whipple ('10) and others, however, think omissions may be important. Both omissions and cancellations are given for all of the groups in this study; but it will be apparent that significance can be attached only to the latter.

Of the tests used, the mixed relations and the completion were given to all subjects. The maze and the cancellation were not employed with the white high school pupils of Richmond, on account of a lack of available time. The maze was also not used with the white elementary pupils of Newport News. The white elementary pupils of Fredericksburg, through an oversight on the part of the experimenter, did not sign their names to the maze test, and their records in this test can consequently be used only in grade and not in age and sex comparisons.

The total time consumed by these tests in the case of any individual subject was small, and it cannot be supposed that the records obtained from a given individual are an accurate index of his relative ability in the traits measured. Further trials would be necessary to establish the final standing of any one of the pupils in the tests. But while this is true, it is also true that the tests are sufficient to establish with accuracy the relative standing of large groups of subjects as wholes, and it is a group—a racial—comparison that is in question. Where a group is tested, the chance inaccuracies which deflect the true position of one individual in one direction serve also to change the position of another individual in the opposite direction, so that on the whole the central tendency of the group remains unchanged from what it would be in the case of a very great number of measurements, the practice effect, of course, being disregarded. The individual inaccuracies balance each other, and the group standing is unaffected by them. It is improbable that many repeated trials would appreciably disturb the average score. This view is taken for granted in all tests upon large numbers of subjects; Thorndike ('04) gives illustrations of its validity. The mixed relations test as herein used is another illustration, as will appear. For the test is given in two parts—is, in reality, two tests—and the relative standing of the groups compared is the same in each. Woodworth and Wells ('11), indeed, recommend a short test of this and related kinds as being better than a long one, since it is freer from interferences of a disturbing character. So the final average results of these tests may confidently be taken as reliable measures of the relative ability of whites and negroes in the traits involved, although the time consumed in the actual testing was short.

CHAPTER III

GENERAL COMPARISON OF WHITES AND NEGROES

In the present chapter a general comparison is made between the scores of the white and the colored subjects. In setting forth the results, the tables and graphs are arranged in the same order for each test. First are given the average scores made by each age and sex and by each grade, with their average deviations. The tables containing these data are the basis of the comparisons made in the other tables, and they also give the figures which are represented by the graphs. The graphs are next in order, and serve to make the group relationships contained in the tables somewhat plainer. It may be noticed that the graphs and the tables of comparison which follow them omit those ages and grades in which there are not figures for both races: no comparison is made unless the ages and grades are alike. The results from Richmond, Fredericksburg and Newport News appear in succession in each table. There are no graphs for the two latter cities.

Following the graphs, for each test come the tables in which the group comparisons are made. First appear the actual differences between the scores obtained by the two races, classified by age and sex and by grades. The averages of the separate age and grade differences are given, with their probable errors. These averages, of course, are the most reliable figures for comparison. Next are the tables which set forth the percentage of the score of the whites which was obtained by the negroes, with the averages of the separate ages and grades and the probable errors of the averages. The tables which show the actual differences between the scores and those which show the percentages deal with the same racial differences, and are simply two ways of exhibiting the same group relationships. Lastly, as still another mode of comparison, for each test is given the percentage of each age and grade of the colored subjects that reaches or exceeds the average score of the white subjects of the same age or grade. The averages and probable errors of the separate age and grade percentages are given as before. This comparison is made only for Richmond, since the relatively small number of pupils tested in Fredericksburg and Newport News would render it somewhat unreliable for those cities. A group comparison by means of the percentage of one group reaching or exceeding the average of the other requires a rather large number of subjects to be of value. If the number is small, chance inequalities in the distribution of the groups may make the percentage appear to be much too high or much too low.

It should be said that this comparison in terms of the percentage of the negroes reaching or exceeding the average of the whites is valid only in so far as the groups follow a normal mode of distribution. That is, the average of the groups must also be approximately the median of the groups. Or to put it in another way, approximately fifty per cent. of the groups must reach or exceed their own average. Otherwise, we would have fifty per cent. of the negroes reaching or exceeding the score obtained by 30 per cent. or 70 per cent., or any indefinite per cent., of the whites. The ideal procedure would be to ascertain the percentage of the negroes reaching or exceeding the median, rather than the average, of the whites. But in the present comparison the averages and the medians of the groups compared are approximately the same, as the following figures will show, and the mode of comparison adopted is a valid one.

In the mixed relations test, the percentage of the whites reaching or exceeding their own average in Test I is 50.0, P.E. 1.7, for all ages of the boys; 53.5, P.E. 2.2, for all ages of the girls; and 54.8, P.E. 1.6, for all grades. (The grades contain both boys and girls). In Test II the percentage for boys, all ages, is 55.0, P.E. 2.3; for girls, all ages, it is 55.9, P.E. 2.2; and for all grades it is 55.6, P.E. 2.1. It is thus evident that for the white subjects in this test the average and the median are approximately the same, and that the groups follow a sufficiently normal form of distribution for the percentage comparison to be made in terms of the average rather than of the median. The figures showing the percentage of the colored subjects reaching or exceeding their own average are as follows: Test I—boys of all ages, 48.4, P.E. 2.4;

girls of all ages, 48.7, P.E. 2.3; all grades, 48.5, P.E. 1.4. Test II—boys of all ages, 52.1, P.E. 2.5; girls of all ages, 51.2, P.E. 3.3; all grades, 52.0, P.E. 1.9. Thus the colored subjects are also seen to be so distributed that their central tendency is approximately the same whether measured by average or by median. It worthy of note that the percentage of subjects reaching or exceeding their own average is somewhat higher in Test II than in Test I. This is due to the fact that the scores themselves in Test II are higher than in Test I, on account of the practice effect of Test I, to such extent that several of the brighter subjects finished the second test before the time limit was reached, and thus did not attain their possible maximum score. This lowers the average standing in Test II so that more than fifty per cent. of the subjects reach or exceed it. This occurs for both races, though slightly more so for the whites than for the negroes, since the score of the whites was greater, as will appear, and more of them finished the test before the expiration of the time limit. A slightly larger percentage of the negroes, as will also appear, reached the average of the whites in Test II than in Test I. But this should not be taken to indicate that the negroes profited more by the practice in the first test than did the whites: both races reached or exceeded their average in greater numbers in the second test.

In the completion test, the percentages of white subjects reaching or exceeding their own average are: boys, all ages, 50.2, P.E. 2.0; girls, all ages, 52.2, P.E. 1.3; all grades, 52.7, P.E. 1.2. The percentages of colored subjects reaching their own average are: boys, all ages, 52.6, P.E. 2.6; girls, all ages, 54.2, P.E. 2.1; all grades, 54.4, P.E. 1.3. In this test, as in the mixed relations, the average and the median are approximately the same.

The maze test shows the following percentages of white subjects reaching or exceeding their own average: boys, all ages—Touches, 50.0, P.E. 3.3, Distance, 52.0, P.E. 1.6; girls, all ages—Touches, 52.4, P.E. 2.4, Distance, 46.8, P.E. 2.8; all grads—Touches, 48.2, P.E. 2.7, Distance, 49.0, P.E. 2.9. The percentages of colored subjects reaching or exceeding their own average in the maze test are: boys, all ages—Touches, 46.6, P.E. 1.9, Distance, 46.4, P.E. .9; girls, all ages—Touches, 45.6, P.E., .9, Distance, 44.4, P.E. 1.8; all grades—Touches, 47.8, P.E. 2.1, Distance, 51.2, P.E. 2.3.

In the cancellation test, the percentage of a group reaching its own average or the average of another group can be validly computed only for the cancellations, not for the omissions. Less than half of the subjects made any omissions at all, and the distribution of the omissions is consequently very assymmetrical. The percentages of whites reaching or exceeding their own average in cancellations are as follows: boys of all ages, 53.0, P.E. 1.3; girls of all ages, 49.6, P.E. 1.9; all grades, 49.3, P.E. 1.4. The percentages of negroes reaching or exceeding their own average in cancellations are: boys of all ages, 50.0, P.E. 3.6; girls of all ages, 52.2; P.E. 3.7; all grades, 53.7, P.E. 1.5.

These figures make it evident that we can compare the white and colored subjects in terms of the percentage of the colored reaching or exceeding the average of the white, since the distributions throughout are on the whole symmetrical.*

Perhaps something should also be said as to the other tables of comparison, those which show the actual differences between the scores of the two races and those which show the percentage of the score of the whites that is obtained by the negroes. It sometimes happens that investigators average the scores of a number of different ages or grades, and make comparisons by exhibiting the relation between such averages. But this procedure makes it impossible to compute the probable error of the differences, and thus renders the comparisons doubtful. If, for example, scores from ages 11 to 18 are averaged for two races, and a certain difference between the averages is set forth, one cannot tell from this difference alone whether any real racial superiority has been found.

*Note may be made of the fact that in a few ages and grades no colored subjects reached or exceeded the average of the whites, and that the percentage in such cases was put down as zero. But such percentages are really less than zero. And when they are counted as zero, as they are, in obtaining the average for all ages or grades, it is obvious that this procedure tends to make the average percentage too high. That is, it tends to make the racial difference appear to be less than it really is.

Another matter that also makes the racial differences found appear to be less than they really are, is the fact that in the tables which show the percentage of the score of the whites obtained by the negroes, the percentages are always expressed in terms of the white score. Hence whenever the negroes have a higher score than the whites, as they do in a few instances, the percentage expressing the fact is disproportionately large. For example, if the whites score 100 and the negroes score 75, the percentage is 75; but if the whites score 75 and the negroes score 100, the percentage is 133. These considerations affect the final averages only slightly, but they should be borne in mind.

It may be that the separate ages show a superiority first in favor of one race and then in favor of the other, and so on. What is needed to determine the validity of the difference is its probable error. This will indicate how constant the difference is from age to age—whether it is a true difference or is due to chance. Of course it will be recognized that probable errors can be computed for the averages of a number of different age or grade scores. But such probable errors will be larger than the racial variability from age to age would warrant, since scores normally increase with age. And they therefore cannot be used as accurate measures of the probable error of the racial difference.

Where, as in the tables of comparison contained herein, the differences between the scores of the separate ages are found, the average of these differences can be obtained and also the probable error of the average. If the differences for the separate ages are pronouncedly in favor of one of the two races, the probable error will be small as compared with the average. Even though slight, the average difference will indicate a real racial superiority if its probable error is small. But if the differences between the separate ages are chance differences which favor first one race and then the other, no matter if the average difference is large, it will yet be seen to be no true index on account of its large probable error. This principle is as applicable to those of the following tables which exhibit the percentage of the score of the whites obtained by the negroes, as it is to those which set forth the actual differences. In the percentage tables also, the average of the different ages is computed and its probable error is given with it.

Mixed Relations Test

The scores obtained by the two races in this test are shown in Tables 5 and 6, and in Figures 1-6. It may be noted that in Test II the scores are somewhat higher than in Test I. This is evidently due to the practice that the first test afforded. It may also be noted, (Figs. 3 and 6), that there is a pronounced jump in the scores of the colored grades when high school is reached, and that this jump does not occur in the scores of the white grades. This is probably the effect of the more intense action of selection upon the colored than upon the white high school pupils, as was pointed out in the preceding chapter. In some of the high school years the colored are superior to the white subjects, but this does not occur in the elementary school.

TABLE V.

MIXED RELATIONS TEST—SCORES BY AGE AND SEX

Richmond.

Ages	10	11	12	13	14	15	16	17	18	19
Test I.										
Boys—white										
Av.	..	14.8	16.5	18.3	18.0	20.1	27.8	25.6	25.0	..
A.D.	..	6.6	7.3	8.7	7.3	10.0	5.9	8.1	4.0	..
Boys—Col.										
Av.	..	11.5	10.2	11.8	13.7	12.9	20.5	22.0	20.0	15.3
A.D.	..	3.8	4.4	5.0	6.5	6.9	8.4	8.5	8.4	7.6
Girls—white										
Av.	..	16.9	18.8	18.0	22.7	23.0	25.0	19.8	16.6	18.5
A.D.	..	6.0	4.2	7.4	8.3	8.6	7.4	6.2	3.8	.5
Girls—Col.										
Av.	10.0	12.4	10.6	12.4	14.5	18.6	21.1	26.0	18.4	22.6
A.D.	5.3	4.4	4.8	6.0	7.5	9.1	6.8	6.8	8.4	9.3
Test II.										
Boys—white										
Av.	..	16.5	19.5	21.3	24.1	22.0	33.0	34.6	29.6	..
A.D.	..	8.0	9.3	9.2	9.5	11.9	5,5	5.2	4.6	..
Boys—Col.										
Av.	..	12.6	11.6	13.7	16.3	19.2	25.7	32.0	32.1	31.2
A.D.	..	8.1	6.6	5.8	10.0	11.0	8.5	7.1	7.1	3.7
Girls—white										
Av.	..	22.0	22.4	21.5	24.7	28.6	31.7	27.8	23.0	18.5
A.D.	..	6.4	8.2	8.5	10.7	7.4	6.9	7.2	11.4	1.5
Girls—Col.										
Av.	14.0	17.2	10.6	11.8	16.4	22.1	27.9	31.9	22.7	24.0
A.D.	4.0	5.0	4.7	6.6	10.8	9.1	6.8	7.1	9.2	5.3

Fredericksburg.

Ages	10	11	12	13	14	15	16	17	18	19
Test I.										
Boys—white										
Av.	..	10.6	20.5	14.4	23.1	27.5	23.5	28.8	38.0	..
A.D.	..	4.0	12.5	6.4	10.7	9.4	13.1	8.5	2.0	..
Boys—Col.										
Av.	..	..	11.3	9.5	..	14.0	11.2	..	22.0	19.5
A.D.	..	..	1.6	3.5	..	5.3	2.6	..	0	8.5
Girls—white										
Av.	..	..	20.5	19.5	22.5	19.3	16.6	26.8	20.5	..
A.D.	..	..	11.1	6.1	11.1	14.0	8.0	9.6	10.5	..
Girls—Col.										
Av.	..	..	..	10.7	10.5	6.0	28.5	21.3	13.5	18.5
A.D.	..	..	..	4.7	1.9	4.0	8.5	8.9	6.5	7.5
Test II.										
Boys—white										
Av.	..	22.6	23.5	17.8	26.5	33.4	32.1	34.0	38.0	..
A.D.	..	6.6	15.2	10.8	12.5	7.5	6.5	6.8	1.3	..
Boys—Col.										
Av.	..	..	13.3	8.5	..	20.3	19.0	..	29.0	22.7
A.D.	..	..	5.0	.5	..	9.6	7.6	..	2.0	13.2
Girls—white										
Av.	..	..	25.8	19.1	29.0	22.6	24.8	32.2	28.0	..
A.D.	..	..	12.1	7.1	9.7	8.3	5.5	7.0	8.0	..
Girls—Col.										
Av.	..	..	..	13.3	11.0	16.0	35.0	27.6	23.0	21.0
A.D.	..	..	..	8.1	2.8	12.0	3.0	5.8	9.0	16.0

Newport News.

Ages	10	11	12	13	14	15	16	17	18	19
Test I.										
Boys—white										
Av.........	..	27.6	16.4	20.9	18.9	15.2	..	..	..	..
A.D........	..	3.3	6.4	8.3	5.3	4.7	..	..	..	..
Boys—Col.										
Av.........	..	..	13.5	..	7.0	..	..	..	..	..
A.D........	..	..	9.5	..	1.0	..	..	..	..	..
Girls—white										
Av.........	..	19.6	23.1	18.7	16.3	10.7	24.5	..	..	..
A.D........	..	4.6	6.6	7.3	7.1	4.7	1.5	..	..	..
Girls—Col.										
Av.........	..	..	7.7	7.0	6.0	2.0	8.6	..	..	..
A.D........	..	..	4.1	1.0	1.8	0	6.6	..	..	..
Test II.										
Boys—white										
Av.........	..	33.6	24.4	24.7	20.8	21.0	..	..	..	..
A.D........	..	3.3	7.1	9.4	8.3	5.2	..	..	..	..
Boys—Col.										
Av.........	..	..	21.5	..	7.0	..	..	..	..	..
A.D........	..	..	15.5	..	1.0	..	..	..	..	..
Girls—white										
Av.........	..	30.4	30.9	23.9	22.0	12.5	31.0	..	..	..
A.D........	..	2.4	5.6	7.8	10.2	10.0	3.0	..	..	..
Girls—Col.										
Av.........	..	..	9.4	4.2	6.8	4.6	4.0	..	..	..
A.D........	..	..	3.0	2.6	2.4	3.3	1.3	..	..	..

TABLE VI.

MIXED RELATIONS TEST—SCORES BY GRADES

Richmond.

Grades	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
Test I.											
White Av.........	13.1	13.9	16.8	16.8	18.4	24.9	25.5	28.0	..	23.1	23.3
A.D.	6.5	4.0	4.6	6.2	5.8	6.9	7.3	6.8	..	7.2	8.6
Col. Av...........	8.9	10.3	13.0	13.4	9.7	12.2	21.4	20.7	17.7	29.4	22.6
A.D.	3.5	3.1	5.9	5.2	5.1	6.3	6.8	7.7	6.1	4.4	9.3
Test II.											
White Av.........	14.8	18.0	19.8	22.6	21.8	29.4	29.0	33.6	..	31.8	30.2
A.D.	7.0	6.2	9.2	7.5	9.1	8.5	7.9	5.2	..	6.9	7.8
Col. Av...........	9.7	10.3	14.0	13.9	16.5	11.8	27.1	28.1	24.0	35.4	29.6
A.D.	4.8	5.6	6.7	7.1	8.2	6.6	8.5	6.9	8.0	2.6	8.2
Fredericksburg.											
Test I.											
White Av.........	..	..	16.2	..	18.5	..	23.1	22.6	..	26.3	30.8
A.D.	..	..	8.1	..	10.0	..	9.8	12.8	..	9.8	7.1
Col. Av...........	..	..	10.7	..	8.2	..	13.6	16.2	..	22.5	24.2
A.D.	..	..	2.7	..	4.5	..	4.8	6.2	..	9.8	6.2
Test II.											
White Av.........	..	..	19.1	..	22.0	..	32.5	27.8	..	32.9	34.3
A.D.	..	..	10.1	..	11.0	..	6.7	8.8	..	5.2	6.9
Col. Av...........	..	..	10.6	..	11.1	..	20.6	23.5	..	30.3	30.1
A.D.	..	..	3.8	..	4.7	..	9.0	6.1	..	7.8	7.1
Newport News.											
Test I.											
White Av.........	..	..	..	15.7	22.5	20.6	..	..	..	..	..
A.D.	..	..	..	6.8	6.1	7.3	..	..	..	..	..
Col. Av...........	..	..	7.8	..	7.4	..	..	..	..	..	..
A.D.	..	..	3.5	..	3.6	..	..	..	..	..	..
Test II.											
White Av.........	..	..	..	23.2	24.9	25.5	..	..	..	..	..
A.D.	..	..	..	9.1	8.2	8.6	..	..	..	..	..
Col. Av...........	..	..	8.5	..	7.1	..	..	..	..	..	..
A.D.	..	..	4.3	..	3.8	..	..	..	..	..	..

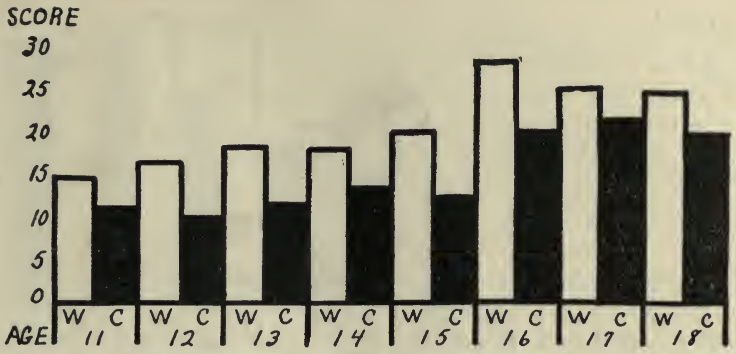

Fig. 1. Mixed Relations Test I—Scores of White and Colored Boys—Richmond.*

*The white and the black columns indicate the scores of the white and the colored subjects, respectively.

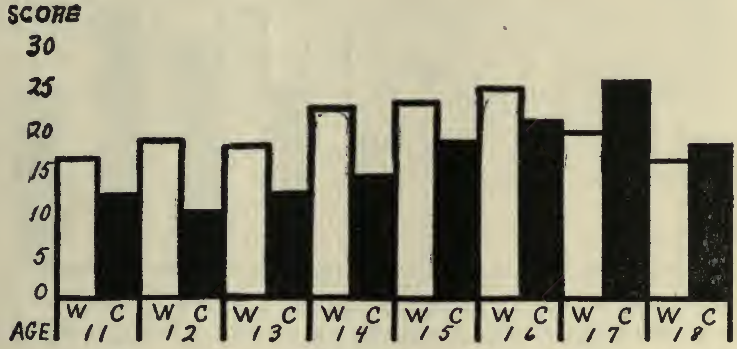

Fig. 2. Mixed Relations Test I—Scores of White and Colored Girls—Richmond.

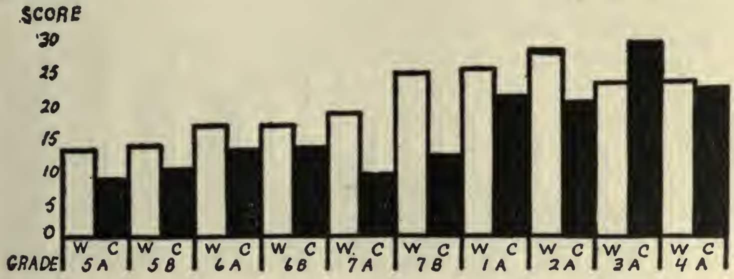

Fig. 3. Mixed Relations Test I—Scores of White and Colored Grades—Richmond.

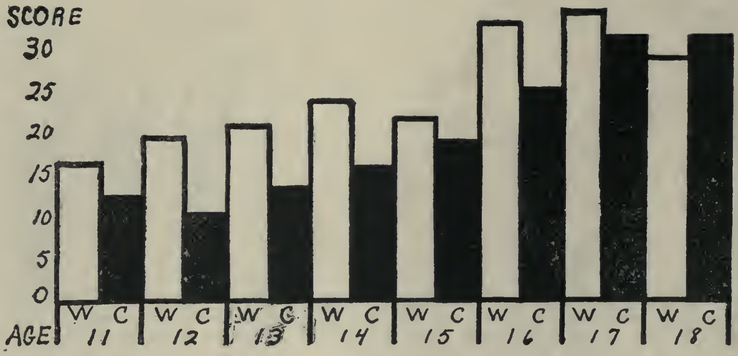

Fig. 4. Mixed Relations Test II—Scores of White and Colored Boys—Richmond.

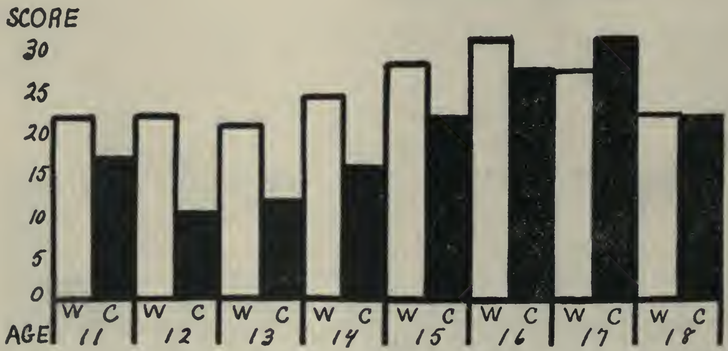

Fig. 5. Mixed Relations Test II—Scores of White and Colored Girls—Richmond.

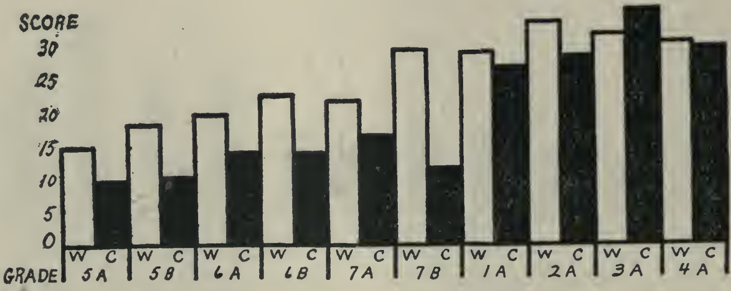

Fig. 6. Mixed Relations Test II—Scores of White and Colored Grades—Richmond.

It is interesting to note that the gradual increase in the scores as the age of the subjects increases comes to a standstill in the upper years; indeed, the graphs show that the older pupils as a whole have somewhat lower scores than those immediately below them in age. This is to be expected. In a group of pupils taken from any limited number of school grades, those whose ages are highest will not do as well in tests of ability as their ages would seem to warrant. When the elementary school pupils alone are classified by age their scores do not progressively increase, but instead tend to decrease in the upper years as do those of the high school pupils represented in the graphs. The white elementary pupils tested in Richmond ranged, in numbers large enough for comparison, from 11 to 15 years of age, inclusive. And their scores for each age were as follows: Mixed Relations Test I—Boys, 14.8, 15.0, 17.3, 16.0, 13.7; Girls, 16.9, 18.8, 17.0, 17.2, 15.2. Mixed Relations Test II—Boys, 16.5, 18.0, 20.6, 22.1, 15.0; Girls, 22.0, 22.1, 21.0, 17.4, 16.7. The scores for the different ages of colored elementary pupils behaved in the same way. It is thus evident that there is precisely the same sort of decrease in the scores of the higher ages that was found for the high school pupils.

The explanation of this decrease with age is probably to be sought in the bearings of the general fact that within any school grade the younger pupils have greater natural ability than the older. If the older pupils had had great ability, they would have passed out of the grade; that the younger pupils are so advanced as to be classed with the older pupils is evidence of their considerable capacity. The younger pupils in a shorter length of time have done the same amount of work that the older pupils have done in a greater length of time. A grade contains the best of the young and the worst of the old. So when the pupils in the upper grades of the elementary school are classified by age, it is apparent that the older pupils will be those of less native ability and the younger pupils will be those of greater native ability. The younger pupils in the upper elementary grades are the best of their age; the older pupils are the poorest of their age. The poor and mediocre pupils of the same age as the younger group have not yet reached the higher grades of the elementary school; the able pupils of the same age as the older group have passed on into high school. The same reasoning applies to the school system as a whole, including the high school as the highest grades. The older pupils in the upper grades of the high school have not as great natural ability as the younger pupils. The ablest pupils of the same age as the older group have finished the high school course, and left behind only the mediocre and the poor. But the younger group is composed of the brightest pupils of their age, for those of less ability have not yet reached the upper grades. That this explanation of the smaller scores made by the oldest pupils tested is pertinent, is further indicated by the fact that the graphs which give the scores by grades do not show the decrease for the advanced pupils as it is shown by the graphs which give the scores by ages. Grades are supposedly groups of an increasing degree of ability.

The truth of the view set forth above is still further borne out by an incidental comparison that came to light in the present investigation. In the elementary schools at Richmond were tested 30 white boys, 20 white girls, 24 colored boys and 38 colored girls, 112 in all, of ages 14 and 15, combined. In the high schools at Richmond were tested 18 white boys, 25 white girls, 10 colored boys and 31 colored girls, 84 in all, of ages 14 and 15, combined. It is true that there was a larger proportion of 14 than of 15 year old pupils in the elementary groups, and a larger proportion of 15 than of 14 year old pupils in the high school groups. But this is of no consequence, since the 14 year old elementary pupils are fully as able as those 15 years old, as was shown two paragraphs above; and since the same thing is true of 14 and 15 year old pupils in the high school, as will be shown three paragraphs below. So these groups may be considered as of the same age, one set being in the elementary school and one set in the high school. The scores obtained by them in three tests were as follows:

Mixed Relations Test I—White Boys, Elementary, 14.8, High School, 24.1; White Girls, Elementary, 16.2, High School, 27.7; Colored Boys, Elementary, 10.2, High School, 22.0; Colored Girls, Elementary, 8.9, High School, 23.9. Mixed Relations Test II—White Boys, Elementary, 18.5, High School, 28.6; White Girls, Elementary, 17.0, High School, 33.7; Colored Boys, Elementary, 12.3, High School, 31.8; Colored Girls, Elementary, 10.2, High School, 29.0. Completion Test—White Boys, Elementary, 18.4, High School, 28.6; White Girls, Ele-

mentary, 16.1, High School, 33.1; Colored Boys, Elementary, 12.6, High School, 23.5; Colored Girls, Elementary, 15.6, High School, 25.4. The maze and cancellation tests did not bring out marked differences anywhere, as will appear, and the differences revealed by them in this comparison of the elementary and high schools were not considerable.

These figures show that the white high school pupils obtained on the whole nearly twice the score that was reached by the elementary pupils of the same age; and that the colored high school pupils obtained on the whole more than twice the score that was received by the equally old elementary pupils. Thus is borne out the contention that the older pupils in the upper grades of the elementary school are the poorest of their age; the brightest of their age have passed beyond the elementary school. And it is reasonable to suppose that the same state of affairs exists in the upper high school grades. The able 18 year old students have gone out of the school and left behind their less able fellows. And these are inferior to pupils of normal high school ability at a lower age.

It follows as a corollary of the above, that the youngest pupils represented in the graphs have scores which are too high to be truly representative of their ages. The lowest ages in any limited number of grades contain only the brightest pupils of those ages; the mediocre and the dull have not yet reached the grades in question. While the highest ages score too low, the lowest ages score too high. So it appeared that the youngest and the oldest pupils in the elementary grades tested in Richmond stood close together in their scores, and this was probably on account of the undue superiority of the young as much as on account of the undue inferiority of the old. The same is true of the high school taken alone. Ages 14 to 18, inclusive, were represented in the Richmond high schools in sufficient numbers for comparison. The scores received by the different ages of both white and colored pupils behaved in the same way; the scores of the white high school pupils follow: Mixed Relations Test I—Boys, 23.1, 25.2, 31.3, 25.6, 25.0; Girls, 30.3, 25.2, 25.6, 20.1, 16.6. Mixed Relations Test II—Boys, 29.0, 28.3, 36.8, 34.6, 29.6; Girls, 35.4, 32.0, 32.5, 28.0, 23.0. As in the case of the elementary school, the oldest and the youngest high school pupils do not stand far apart in their scores. And as the older pupils scored too low, so the younger pupils scored too high. This is evidenced by the fact that when all of the pupils of their age, both elementary and high school, are considered together, the resulting score, which is the true one, is much lower. Of course it is the combined score of both high school and elementary pupils of the same age that is represented in the tables and graphs.

This suggests a matter to which attention should be called. The attempt is sometimes made to establish norms for various ages of pupils in psychological tests. The idea is to ascertain by a large number of experiments the performance that may be expected from a child of a certain age. But it is very evident that such attempts can only serve to mislead if they deal, say, with pupils in the higher elementary grades without taking the high school into consideration, or if they deal with the lower grades of the high school without taking the elementary school into consideration. In the former case, the resulting norms for the higher ages will be much too low; in the latter case, for the same ages, they will be much too high. A fourteen or fifteen year old child in the school system is not a typical fourteen or fifteen year old child. He is typical of a child of his age in high or in elementary school, and not in general. The only way in which valid age norms may be established is by testing the ages throughout their normal distributions among the grades. Or if only one school is tested, the elementary or the high school, it should at least be stated that such is the case, so that one may be able to make proper allowances for the findings reported. Even this has not always been done.

Attention may also be called to the bearing of the comparatives scores of the elementary and high school pupils of the same age upon a contention that was made in the preceding chapter. These scores show that the high school pupils are superior to the elementary school pupils of equal age to a considerably greater extent in the case of the negroes than of the whites. The high school negroes more than doubled the score of the elementary school negroes in each of the four comparisons in the mixed relations test, but the high school whites did not double the score of the elementary whites in any of the four comparisons; in the completion test, the high school doubled the score of the elementary school only in the case of the white girls. This fits in with the other indications that the colored high school is a more closely selected group from the point of view of ability than is the white high school.

TABLE VII.

MIXED RELATIONS TEST—DIFFERENCE BETWEEN SCORES OF WHITE AND COLORED SUBJECTS CLASSIFIED BY AGE AND SEX

(Minus signs indicate greater scores by the colored subjects.)

Richmond.

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Test I.										
Boys	3.3	6.3	6.5	4.3	7.2	7.3	3.6	5.0	5.4	.4
Girls	4.5	8.2	5.6	8.2	4.4	3.9	—6.2	—1.8	3.3	1.1
Test II.										
Boys	3.9	7.9	7.6	7.8	2.8	7.3	2.6	—2.5	4.7	.9
Girls	4.8	11.8	9.7	8.3	6.5	3.8	—4.1	.3	5.1	1.2

Fredericksburg.

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Test I.										
Boys	..	..	4.9	..	13.5	12.3	..	16.0	11.7	1.4
Girls	..	..	8.8	12.0	13.3	—11.9	5.5	7.0	5.8	2.1
Test II.										
Boys	..	..	9.3	..	13.1	13.1	..	9.0	11.1	.8
Girls	..	..	5.8	18.0	6.6	—10.2	4.6	5.0	4.9	1.8

Newport News.

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Test I.										
Boys	..	2.9	..	11.9	..	..	..	..	7.4	2.7
Girls	..	15.4	11.7	10.3	8.7	..	..	..	11.5	.8
Test II.										
Boys	..	2.9	..	13.8	..	..	..	..	8.3	3.2
Girls	..	21.5	19.7	15.2	7.9	..	..	..	16.1	1.9

TABLE VIII.

MIXED RELATIONS TEST—DIFFERENCE BETWEEN SCORES OF WHITE AND COLORED SUBJECTS CLASSIFIED BY GRADES

(Minus signs indicate greater scores by the colored subjects.)

Richmond.

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Test I......	4.2	3.6	3.8	3.4	8.7	12.7	4.1	7.3	—6.3	.7	4.2	.8
Test II.....	5.1	7.7	5.8	8.7	5.3	17.6	1.9	5.5	—3.6	.6	5.5	.9

Fredericksburg.

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Test I......	..	..	5.5	..	10.3	..	9.5	6.4	3.8	6.6	7.0	.7
Test II.....	..	..	8.5	..	10.9	..	11.9	4.3	2.6	4.2	7.1	1.6

Newport News.

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Test I......	..	..	..	..	15.1	..	..	..	..	..	15.1	..
Test II.....	..	..	..	..	17.8	..	..	..	..	..	17.8	..

TABLE IX.

MIXED RELATIONS TEST—PERCENTAGE OF THE SCORE OF THE WHITE OBTAINED BY THE COLORED SUBJECTS, CLASSIFIED BY AGE AND SEX

Richmond.

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Test I.										
Boys	78	61	64	76	64	74	86	80	72.9	2.2
Girls	74	57	69	64	81	84	131	111	83.9	5.7
Test II.										
Boys	76	58	64	67	87	78	93	108	78.9	3.9
Girls	78	46	54	67	78	88	115	99	78.1	5.1

Fredericksburg.

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Test I.										
Boys	..	..	65	..	50	47	..	58	55.0	2.7
Girls	..	..	54	45	30	170	80	65	74.0	11.9
Test II.										
Boys	..	..	48	..	60	59	..	76	60.7	3.2
Girls	..	..	69	38	71	141	86	82	81.2	7.7

Newport News.

Test I.										
Boys	..	82	..	37	..	..	..	..	59.5	13.2
Girls	..	33	38	36	21	..	..	..	32.0	2.3
Test II.										
Boys	..	88	..	34	..	..	..	..	61.0	16.2
Girls	..	31	18	31	34	..	..	..	28.5	2.3

TABLE X.

MIXED RELATIONS TEST—PERCENTAGE OF THE SCORE OF THE WHITE OBTAINED BY THE COLORED SUBJECTS, CLASSIFIED BY GRADES

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Richmond.												
Test I.	68	74	78	80	52	49	84	74	127	97	78.3	3.9
Test II.	66	57	71	62	76	39	93	84	111	98	75.7	4.4
Fredericksburg.												
Test I.	..	..	66	..	43	..	59	72	85	79	67.3	3.8
Test II.	..	..	55	..	50	..	63	85	92	88	72.2	5.6
Newport News.												
Test I.	..	..	..	..	31	..	..	..	..	..	31.0	..
Test II.	..	..	..	..	29	..	..	..	..	..	29.0	..

TABLE XI.

MIXED RELATIONS TEST—PERCENTAGE OF COLORED SUBJECTS REACHING OR EXCEEDING THE AVERAGE OF THE WHITE, BY AGE AND SEX AND BY GRADES

Richmond.

Ages	11	12	13	14	15	16	17	18			Av.	P.E.
Test I.												
Boys	33	14	21	37	15	25	33	17	..	..	24.4	2.2
Girls	22	11	26	21	32	33	78	53	..	..	34.5	4.5
Test II.												
Boys	33	15	16	28	47	21	56	67	..	..	35.4	4.8
Girls	25	10	15	29	37	42	74	53	..	..	35.6	4.8
Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A		
Test I.	21	20	37	22	13	11	34	29	87	56	33.0	4.2
Test II.	18	19	24	18	32	0	62	26	88	52	33.9	5.2

To return to the comparative scores of negroes and whites in the mixed relations test. Tables 7-11 give the detailed comparisons. In every instance, as shown by the averages, the whites surpassed the negroes, and the probable errors are so small as to render the averages very reliable. In Test I, in Richmond, the colored boys obtained 72.9 per cent. of the score of the white boys; the colored girls obtained 83.9 per cent. of the score of the white girls; the colored grades obtained 78.3 per cent. of the score of the white grades. In Test II, the colored boys and girls obtained 78.9 and 78.1 per cent., respectively, of the score of the white boys and girls, and the colored grades scored 75.7 per cent. as high as did the white grades. The figures are very constant. We may conveniently average the percentages for boys, girls and grades, and find that in Test I the colored pupils obtained 78.4 per cent. of the score of the whites, and that in Test II they obtained 77.6 per cent. of the white score. In Fredericksburg and Newport News the percentage of the score of the whites obtained by the negroes was considerably smaller than in Richmond.

The figures showing the percentage of Richmond negroes reaching or exceeding the average of the whites are as follows: Test I—Boys, 24.4; Girls, 34.5; Grades, 33.0. Test II—Boys, 35.4; Girls, 35.6; Grades, 33.9. Averaging the percentages for boys, girls and grades, we find that in Test I 30.6 per cent. of the negroes reached or exceeded the white score, and that in Test II 35.0 per cent. of them reached or exceeded the score of the whites.

It is apparent that this test reveals a considerable difference between the two races. In both the first and second tests the difference is about equally marked, and it is approximately the same for both boys and girls and for both ages and grades.

Completion Test

The actual scores in the Completion Test appear in Tables 12 and 13, classified by age and sex and by grades. These tables are the basis of Figures 7-9, and of Tables 14-18, in which the detailed comparisons are made. In this test, as in the mixed relations, though to a less degree, may be noted the relative superiority of the higher colored grades, and the fact that the higher ages, on the whole, do not show progressively increasing scores as do the lower ages.

TABLE XII.

COMPLETION TEST—SCORES BY AGE AND SEX

Richmond.

Ages	10	11	12	13	14	15	16	17	18	19
Boys—white										
Av........	..	15.3	18.7	18.7	21.2	23.4	30.7	30.7	25.2	..
A.D.......	..	4.3	7.2	6.9	8.2	6.4	7.4	6.9	5.8	..
Boys—Col.										
Av........	..	8.8	13.2	13.6	15.8	16.1	21.2	28.1	31.3	27.2
A.D.......	..	1.8	2.2	4.8	6.1	8.6	7.8	7.6	5.6	5.2
Girls—white										
Av........	..	18.9	20.9	17.0	25.3	27.7	28.9	30.0	33.2	33.5
A.D.......	..	4.3	5.7	5.0	8.5	8.3	7.8	8.0	3.0	.5
Girls—Col.										
Av........	13.6	16.8	13.9	14.5	17.9	22.0	24.0	28.1	23.9	28.6
A.D.......	4.6	3.1	3.0	3.7	6.3	5.2	5.0	6.3	3.8	.6

Ages	10	11	12	13	14	15	16	17	18	19
Fredericksburg.										
Boys—white										
Av........	..	24.6	12.0	19.1	23.0	23.7	33.0	31.5	43.3	..
A.D.......	..	8.0	4.0	7.2	10.0	9.0	6.0	5.5	3.0	..
Boys—Col.										
Av........	..	..	15.6	10.0	..	22.0	17.2	..	26.5	24.5
A.D.......	..	..	3.3	3.0	..	10.0	5.4	..	2.5	6.5
Girls—white										
Av........	..	..	24.4	16.5	25.5	22.5	28.8	39.2	35.0	..
A.D.......	..	..	6.0	6.1	6.0	4.1	7.1	5.8	0.	..
Girls—Col.										
Av........	..	..	..	15.3	15.0	22.6	25.0	24.2	11.0	28.0
A.D.......	..	..	..	4.5	3.2	4.6	8.0	8.0	4.0	13.0
Newport News.										
Boys—white										
Av........	..	25.3	23.2	24.7	20.4	14.8	..	..	..	..
A.D.......	..	2.3	5.6	6.8	5.3	3.2	..	..	..	..
Boys—Col.										
Av........	..	..	16.5	..	14.7	..	..	..	..	..
A.D.......	..	..	2.5	..	2.7	..	..	..	..	..
Girls—white										
Av........	..	30.8	23.0	21.8	21.0	21.5	22.0	..	..	..
A.D.......	..	4.8	5.2	5.2	5.4	3.5	5.0	..	..	..
Girls—Col.										
Av........	..	..	13.5	13.1	12.5	8.6	9.0	..	..	..
A.D.......	..	..	5.7	2.5	4.4	2.0	5.3	..	..	..

TABLE XIII.

Completion Test—Scores by Grades

Grades	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
Richmond.											
White Av.........	13.3	15.1	17.6	22.5	19.4	25.6	27.0	30.5	..	31.2	34.5
A.D............	4.6	4.7	4.6	3.8	5.2	6.8	7.1	6.7	..	5.9	6.0
Col. Av...........	11.3	13.2	14.2	16.5	16.1	15.7	21.8	27.2	23.4	28.4	29.4
A.D............	3.5	2.6	4.1	4.0	4.3	4.4	6.3	6.3	4.5	4.8	5.6
Fredericksburg.											
White Av.........	..	..	17.5	..	21.3	..	26.7	26.5	..	36.0	36.1
A.D............	..	..	7.0	..	6.0	..	7.8	6.4	..	5.1	6.0
Col. Av...........	..	..	13.0	..	19.2	..	18.4	20.7	..	24.2	30.1
A.D............	..	..	3.5	..	4.8	..	3.5	5.0	..	9.7	6.6
Newport News.											
White Av.........	..	..	..	21.9	21.9	23.7	..	..	..	..	..
A.D............	..	..	..	7.5	5.0	6.5	..	..	..	..	..
Col. Av...........	..	..	12.6	..	13.3	..	..	..	..	..	..
A.D............	..	..	3.8	..	4.8	..	..	..	..	..	..

The colored boys in Richmond obtained 78.5 per cent. of the score of the white boys. The colored girls obtained 80.0 per cent. of the score of the white girls. And the colored grades obtained 81.7 per cent. of the score of the white grades. The average for boys, girls and grades is 80.1. In Fredericksburg and Newport News the negroes are more inferior to the whites than in Richmond, as was the case in the mixed relations test. And the difference between the races is about the same for both boys and girls and for both ages and grades.

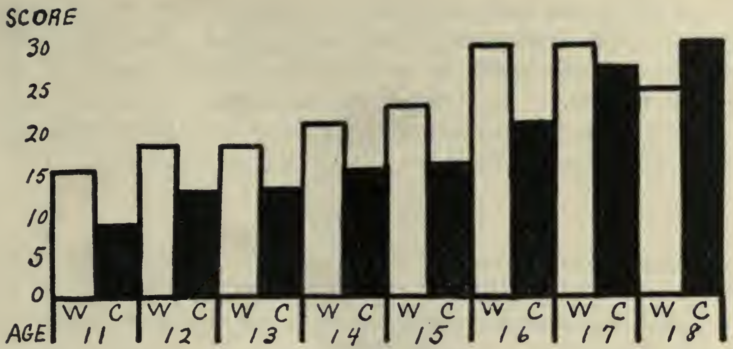

Fig. 7. Completion Test—Scores of White and Colored Boys—Richmond.

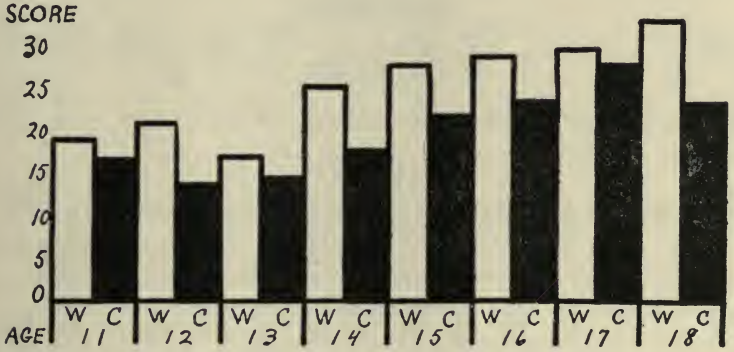

Fig. 8. Completion Test.—Scores of White and Colored Girls—Richmond.

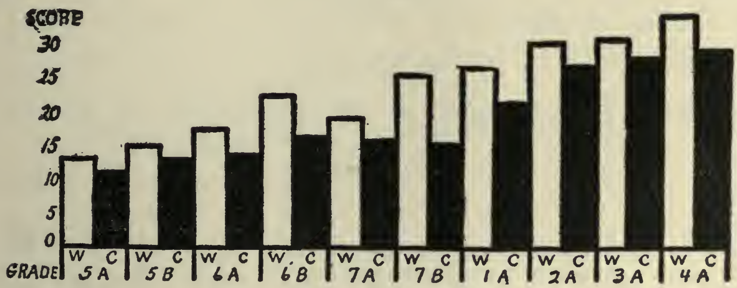

Fig. 9. Completion Test—Scores of White and Colored Grades—Richmond.

In Richmond the percentage of colored boys reaching or exceeding the average of the whites was 32.5. The percentage of colored girls reaching or exceeding the average of the whites was 24.7. By grades, the percentage of colored subjects reaching or exceeding the average of the whites was 26.5. The average for boys, girls and grades is 27.9.

TABLE XIV.

COMPLETION TEST—DIFFERENCE BETWEEN SCORES OF WHITE AND COLORED SUBJECTS CLASSIFIED BY AGE AND SEX

(Minus signs indicate greater scores by the colored subjects.)

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Richmond.										
Boys	6.5	5.5	5.1	5.4	7.3	9.5	2.6	—6.1	4.5	.9
Girls	2.1	7.0	2.5	7.4	5.7	4.9	1.9	9.3	5.1	.7
Fredericksburg.										
Boys	..	..	9.1	..	1.7	15.8	..	16.8	10.8	2.3
Girls	..	..	1.2	10.5	— .1	3.8	15.0	24.0	9.1	2.6
Newport News.										
Boys	..	6.7	..	5.7	..	..	..	..	6.2	.3
Girls	..	9.5	8.7	8.5	12.9	..	..	..	9.9	.3

TABLE XV.

COMPLETION TEST—DIFFERENCE BETWEEN SCORES OF WHITE AND COLORED SUBJECTS CLASSIFIED BY GRADES

(Minus signs indicate greater scores by the colored subjects.)

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Richmond.												
	2.0	1.9	3.4	6.0	3.3	9.9	5.2	3.3	2.8	5.1	4.3	.5
Fredericksburg.												
	..	..	4.5	..	2.1	..	8.3	5.8	11.8	6.0	6.4	.8
Newport News.												
	..	..	..	..	8.6	..	..	..	..	..	8.6	..

TABLE XVI.

COMPLETION TEST—PERCENTAGE OF THE SCORE OF THE WHITE OBTAINED BY THE COLORED SUBJECTS, CLASSIFIED BY AGE AND SEX

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Richmond.										
Boys	57	71	73	74	68	69	92	124	78.5	4.2
Girls	89	67	85	70	80	83	94	72	80.0	2.3
Fredericksburg.										
Boys	..	..	52	..	93	52	..	61	64.5	5.9
Girls	..	..	92	58	100	87	62	31	71.7	7.3
Newport News.										
Boys	..	71	..	71	..	..	..	..	71.0	.0
Girls	..	59	60	60	39	..	..	..	54.5	3.4

TABLE XVII.

Completion Test—Percentage of the Score of the White Obtained by the Colored Subjects, Classified by Grades

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Richmond.												
	85	87	81	73	83	62	81	89	91	85	81.7	1.5
Fredericksburg.												
	..	..	74	..	90	..	69	78	67	83	76.8	2.3
Newport News.												
	..	..	..	..	61	..	..	..	..	..	61.0	..

TABLE XVIII.

Completion Test—Percentage of Colored Subjects Reaching or Exceeding the Average of the White, by Age and Sex and by Grades

Richmond.

Ages	11	12	13	14	15	16	17	18			Av.	P.E.
Boys	0	14	26	35	25	21	56	83	..	..	32.5	5.7
Girls	33	9	41	17	19	24	48	7	..	..	24.7	3.6
Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A		
	33	34	20	15	32	0	26	29	48	28	26.5	2.3

The racial differences are very similar in all respects to those brought out by the mixed relations test. They are equally constant in the two tests, the small probable errors render them equally valid, and they are of approximately equal amounts. This was to be expected, since the two tests deal in general with the same mental traits, and the results from the two serve to reinforce and establish the validity of each other. The results from the two tests and the three cities and in the various modes of comparison make it indubitable that in the important mental capacities measured whites are much superior to negroes.

Just how much the whites are superior in the traits measured it is impossible to say. For we do not know the zero point of the tests. Averaging the results from the mixed relations tests, I and II, and from the completion test, we find that in the tests themselves the negroes did 78.7 per cent. as well as the whites. But we cannot say more than this. We cannot say that the negroes have 78.7 per cent. of the ability of the whites, for we have no index of where the ability in question begins.

Maze Test

The scores for the maze test are set forth in Tables 19 and 20. These tables, so far as they concern Richmond, are made plainer by Figures 10-12. An examination of these figures shows that in every age for each sex, and in every grade except one, the whites covered a greater distance and made more touches than did the negroes. This seems to be a racial difference for the subjects tested. It appears in the Fredericksburg results as well as in those of Richmond. The negroes were more careful than the whites. The significance of this is difficult to tell. And it becomes especially difficult when it is considered in connection with the fact, which will appear, that the negroes were not more careful in the cancellation test.

TABLE XIX.

MAZE TEST—SCORES BY AGE AND SEX

Richmond.

Ages	10	11	12	13	14	15	16	17	18	19
Boys—white										
Touches Av.	..	39.7	48.6	48.2	45.5	57.2	63.3	..	..	..
A.D.	..	20.2	19.6	27.8	26.1	19.5	25.0	..	..	..
Distance Av.	..	94.4	103.2	99.7	99.4	113.8	123.0	..	..	..
A.D.	..	20.2	23.8	27.3	22.6	20.6	22.6	..	..	..
Boys—Col.										
Touches Av.	..	34.4	35.5	31.6	33.7	28.1	14.5	30.0	43.8	16.7
A.D.	..	14.8	23.0	19.7	21.8	22.5	7.7	24.2	31.5	11.7
Distance Av.	..	88.6	90.1	84.4	93.8	83.0	83.2	91.1	104.5	76.0
A.D.	..	12.6	23.9	22.6	28.0	20.2	9.0	23.0	21.5	30.0
Girls—white										
Touches Av.	..	54.0	60.0	41.0	44.3	59.6	..	..	..	..
A.D.	..	16.3	22.6	18.0	26.4	13.3	..	..	..	..
Distance Av.	..	113.7	117.0	110.8	103.8	119.3	..	..	..	..
A.D.	..	13.0	22.0	20.4	25.3	13.7	..	..	..	..
Girls—Col.										
Touches Av.	34.6	21.0	27.2	28.9	35.8	39.0	35.0	21.5	19.2	16.6
A.D.	16.0	15.2	15.9	19.4	22.7	25.4	25.3	16.7	10.5	10.0
Distance Av.	93.6	80.1	84.8	86.2	97.3	101.4	99.0	89.9	86.0	70.6
A.D.	6.0	27.1	23.7	22.9	24.3	17.5	25.5	18.9	17.5	20.6
Fredericksburg.										
Boys—white										
Touches Av.	..	..	..	..	32.4	30.7	17.0	25.3	38.5	..
A.D.	..	..	..	..	21.0	7.2	9.0	15.3	8.3	..
Distance Av.	..	..	..	..	111.2	112.7	88.6	107.0	111.0	..
A.D.	..	..	..	..	19.1	20.2	12.6	23.6	9.3	..
Boys—Col.										
Touches Av.	..	..	26.6	22.5	..	36.6	41.0	..	14.0	34.0
A.D.	..	..	12.6	19.5	..	6.6	36.8	..	6.0	24.5
Distance Av.	..	..	76.3	70.0	..	95.0	80.8	..	69.5	97.5
A.D.	..	..	13.6	26.0	..	14.6	34.0	..	2.5	32.5
Girls—white										
Touches Av.	..	..	..	..	13.6	24.2	11.0	17.6	8.0	..
A.D.	..	..	..	..	4.6	15.2	8.0	9.4	4.0	..

Ages	10	11	12	13	14	15	16	17	18	19
Distance Av.	..	..	..	..	84.6	94.0	85.0	97.4	68.0	..
A.D.	..	..	..	..	7.3	13.5	20.3	5.6	1.0	..
Girls—Col.										
Touches Av.	..	..	..	13.0	11.3	6.3	25.5	10.3	22.0	54.5
A.D.	..	..	..	9.5	6.7	4.3	6.5	7.7	10.0	44.5
Distance Av.	..	..	..	68.7	58.5	58.6	76.0	65.8	84.0	99.5
A.D.	..	..	..	21.2	14.3	14.0	3.0	8.8	0	40.0
					Newport News.					
Boys—Col.										
Touches Av.	..	..	5.0	..	9.5	..	..	..	..	..
A.D.	..	..	3.0	..	3.0	..	..	..	..	..
Distance Av.	..	..	56.5	..	63.5	..	..	..	..	..
A.D.	..	..	7.5	..	11.0	..	..	..	..	..
Girls—Col.										
Touches Av.	..	..	17.4	10.6	7.0	6.0	10.3	..	..	..
A.D.	..	..	20.7	6.6	7.2	4.0	5.0	..	..	..
Distance Av.	..	..	72.2	54.0	59.2	59.3	61.6	..	..	..
A.D.	..	..	23.7	16.0	15.8	6.3	14.0	..	..	..

TABLE XX.

MAZE TEST—SCORES BY GRADES

Richmond.

Grades	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
White											
Touches Av.	53.6	46.9	41.7	38.6	40.2	61.1	..	..	..	..	..
A.D.	22.5	23.4	23.1	22.0	24.8	17.7	..	..	..	..	..
Distance Av.	106.5	106.6	95.5	97.0	103.0	123.7	..	..	..	..	..
A.D.	21.3	24.0	25.3	23.2	22.9	13.7	..	..	..	..	..
Colored											
Touches Av.	38.3	26.0	21.7	18.6	46.1	46.7	31.2	34.3	33.9	20.5	16.8
A.D.	20.6	18.3	13.4	14.7	15.9	26.9	21.3	24.2	23.7	15.2	9.0
Distance Av.	100.4	85.3	70.7	69.5	111.7	103.3	94.6	98.7	101.0	84.2	81.8
A.D.	23.1	21.7	14.5	20.2	15.2	24.5	19.3	18.0	25.0	17.9	20.0
					Fredericksburg.						
White											
Touches Av.	..	..	26.1	..	24.6	..	31.6	13.5	..	19.9	25.8
A.D.	..	..	16.5	..	15.7	..	17.7	8.4	..	11.0	15.3
Distance Av.	..	..	94.2	..	92.2	..	104.6	87.3	..	97.9	102.7
A.D.	..	..	24.4	..	20.4	..	22.3	13.0	..	16.7	17.8
Colored											
Touches Av.	..	..	19.2	..	16.5	..	10.5	21.8	..	24.5	31.7
A.D.	..	..	15.4	..	11.1	..	5.7	16.2	..	14.5	25.7
Distance Av.	..	..	67.1	..	72.1	..	61.2	83.0	..	78.3	90.7
A.D.	..	..	18.8	..	20.4	..	14.2	16.0	..	14.8	28.0
					Newport News.						
Colored											
Touches Av.	..	..	13.1	..	6.8	..	..	..	..	..	..
A.D.	..	..	11.5	..	5.0	..	..	..	..	..	..
Distance Av.	..	..	67.5	..	55.6	..	..	..	..	..	..
A.D.	..	..	16.6	..	13.4	..	..	..	..	..	..

It is not apparent that there is any general increase or decrease in either the distance covered or the number of touches, or in the ratio between the two, as the age of the pupils advances. The difference in ages, indeed, may fairly be disregarded.

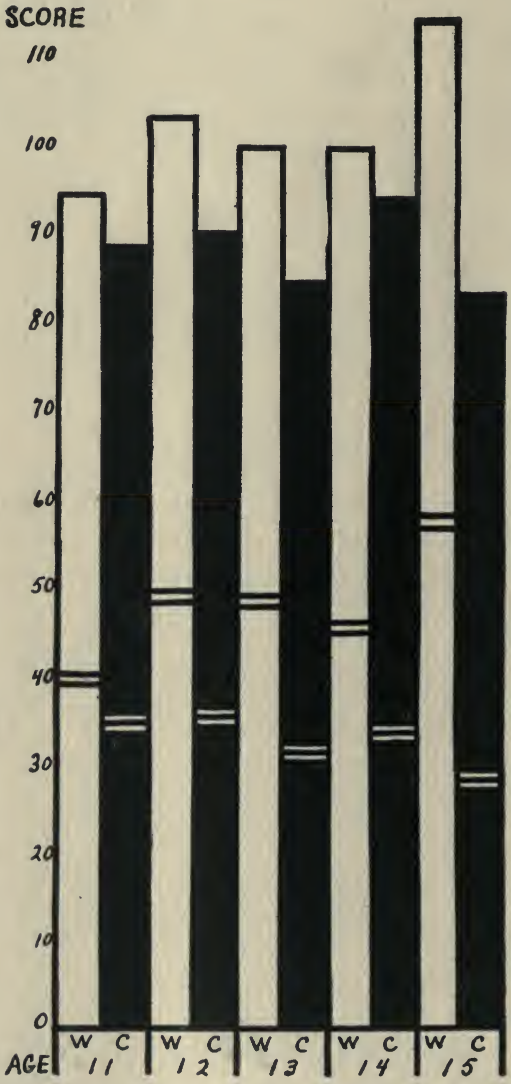

Fig. 10. Maze Test—Scores of White and Colored Boys—Richmond.*

*The total height of the columns indicates the score for distance; the height of the cross-lines indicates the score for touches.

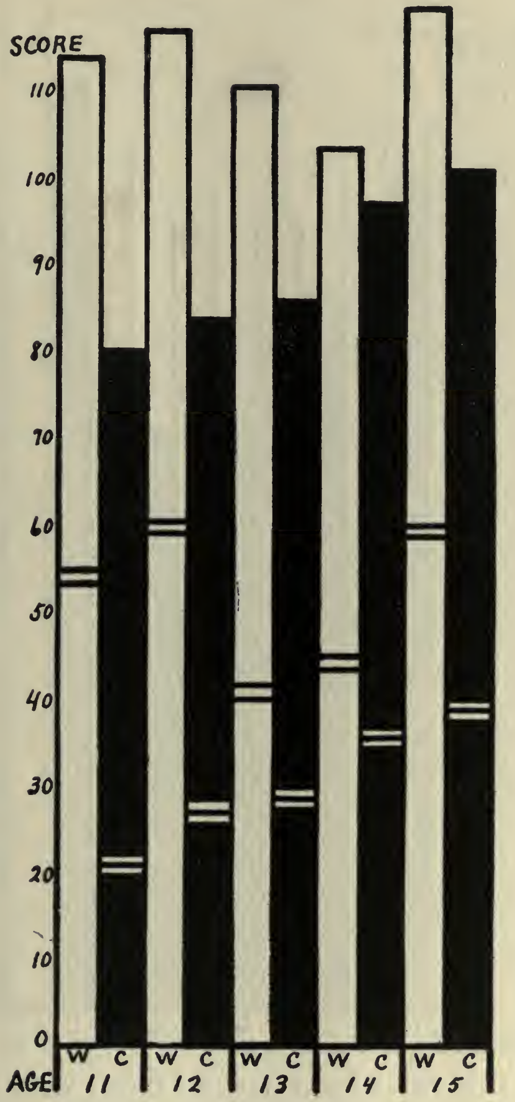

Fig. 11. Maze Test—Scores of White and Colored Girls—Richmond.

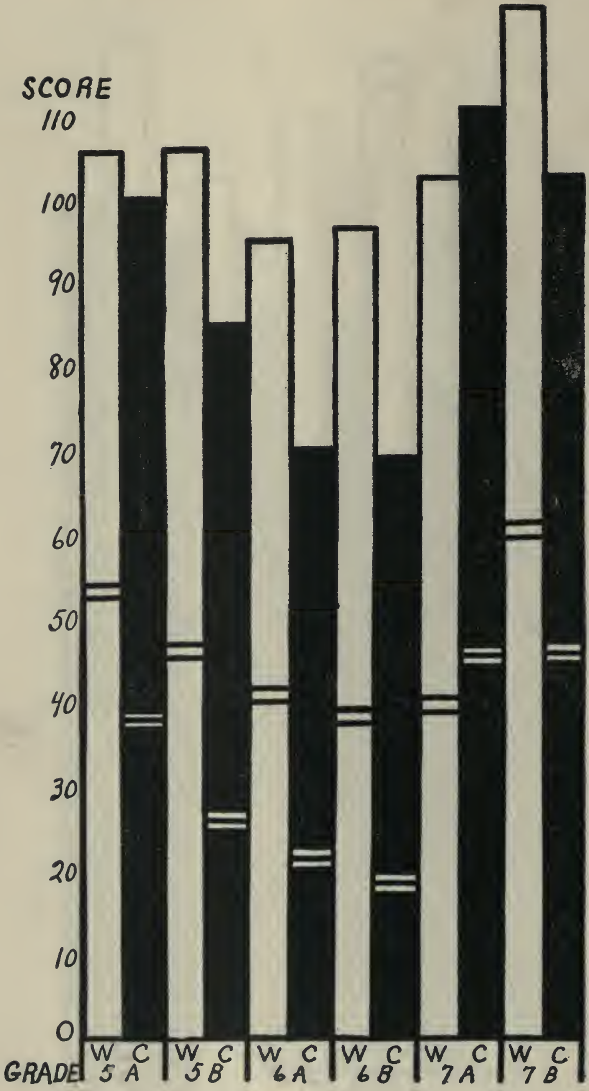

Fig. 12. Maze Test—Score of White and Colored Grades—Richmond.

When we attempt to decide which race was superior in this test we encounter the difficulty in evaluating speed and accuracy that was discussed in the preceding chapter. Tables 21-25 give the detailed comparisons for both speed and accuracy—distance and touches. The Fredericksburg comparisons, on the whole, are fairly sure, although the probable errors are large. The tables show that in Fredericksburg the colored subjects exceeded the white subjects in number of touches made, but were inferior to them in distance covered, and that this was true for both sexes and for the grades. The negroes attained less speed and were at the same time more inaccurate. Consequently they were inferior to the whites.

But in Richmond a conclusion cannot be drawn so readily. Here the colored subjects were slower, as in Fredericksburg, but, unlike those in Fredericksburg, they were also more accurate than the whites. The colored boys covered 86.6 per cent. of the distance covered by the white boys and made 69.6 per cent. as many touches. The colored girls scored 79.8 per cent. of the distance of the white girls and 60.2 per cent. as many touches as the white girls. The scores for the grades show that the colored pupils scored for distance and touches, respectively, 85.2 per cent. and 70.0 per cent. as high as did the white pupils. These figures are fairly uniform for the different classifications of the subjects, and their probable errors are sufficiently small for reliability. If we average the percentages given for boys, girls and grades, we find that the negroes covered 84 per cent. as great distance as the whites and made 67 per cent. as many errors.

TABLE XXI.

MAZE TEST—DIFFERENCE BETWEEN SCORES OF WHITE AND COLORED SUBJECTS CLASSIFIED BY AGE AND SEX

(Minus signs indicate greater scores by the colored subects.)

Richmond.

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Boys										
Touches	5.3	13.1	16.6	11.8	29.1	..	..	..	15.2	2.3
Distance	5.8	13.1	15.3	5.6	30.8	..	..	..	14.1	2.7
Girls										
Touches	33.0	32.8	12.1	8.5	20.6	..	..	..	21.4	3.5
Distance	33.6	32.2	24.6	6.5	17.9	..	..	..	23.0	3.3

Fredericksburg.

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Boys										
Touches	..	..	..	..	—5.9	—24.0	..	24.5	—1.8	8.6
Distance	..	..	..	..	17.7	7.8	..	41.5	22.3	6.3
Girls										
Touches	..	..	..	2.3	17.9	—14.5	7.3	—14.0	—.2	4.3
Distance	..	..	..	26.1	35.4	9.0	31.6	—16.0	17.2	6.3

TABLE XXII.

Maze Test—Difference Between Scores of White and Colored Subjects Classified by Grades

(Minus signs indicate greater scores by the colored subjects.)

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E
					Richmond.							
Touches	15.3	20.9	20.0	20.0	—5.9	14.4	..	..	..	..	14.1	2.3
Distance	6.1	21.3	24.8	27.5	—8.7	20.4	..	..	..	..	15.2	3.8
					Fredericksburg.							
Touches	..	..	6.9	..	8.1	..	21.1	—8.3	—4.6	—5.9	2.9	3.2
Distance	..	..	27.1	..	20.1	..	43.4	4.3	19.6	12.0	21.1	3.3

TABLE XXIII.

Maze Test—Percentage of the Score of the White Obtained by the Colored Subjects, Classified by Age and Sex

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
				Richmond.						
Boys										
Touches	87	73	65	74	49	..	..	..	69.6	3.8
Distance	94	87	85	94	73	..	..	..	86.6	2.2
Girls										
Touches	39	45	70	81	66	..	..	..	60.2	5.7
Distance	70	72	78	94	85	..	..	..	79.8	2.9
				Fredericksburg.						
Boys										
Touches	..	..	..	..	119	241	..	36	132.0	36.1
Distance	..	..	..	..	84	91	..	63	79.3	5.4
Girls										
Touches	..	..	..	84	25	232	59	275	135.0	36.2
Distance	..	..	..	89	62	89	67	124	86.2	6.4

TABLE XXIV.

Maze Test—Percentage of the Score of the White Obtained by the Colored Subjects, Classified by Grades

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
					Richmond.							
Touches	72	56	52	49	115	76	..	..	..	..	70.0	6.3
Distance	94	80	74	72	108	83	..	..	..	..	85.2	3.5
					Fredericksburg.							
Touches	..	..	73	..	68	..	34	164	123	123	97.5	13.5
Distance	..	..	71	..	78	..	59	95	80	88	78.5	3.2

TABLE XXV.

Maze Test—Percentage of Colored Subjects Reaching or Exceeding the Average of the White, by Age and Sex and by Grades

Ages	11	12	13	14	15		Av.	P.E.
				Richmond.				
Boys								
Touches	40	20	22	29	14	..	25.0	2.9
Distance	40	30	39	35	14	..	31.6	2.9

Ages	11	12	13	14	15		**Av.**	**P.E.**
Girls								
Touches	0	10	35	30	22	..	**19.4**	**4.5**
Distance	25	20	29	41	19	..	**26.8**	**2.5**
Grades	5A	5B	6A	6B	7A	7B		
Touches	26	19	14	14	68	35	**29.3**	**5.2**
Distance	41	22	11	14	68	35	**31.8**	**5.6**

The percentages of colored subjects reaching or exceeding the average of the white show the same relative standing for the two races in touches and distance traversed as is evident from the preceding figures. These percentages are as follows: Boys—Touches, 25.0, Distance, 31.6; Girls—Touches, 19.4, Distance, 26.8; Grades—Touches, 29.3, Distance, 31.8. If we average the percentages for boys, girls and grades, as before, we find that 25 per cent. of the negroes reached the average of the whites in touches, and that 30 per cent. of them reached the average of the whites in distance.

Do these facts indicate that the colored subjects were superior, inferior or equal to the white? A reference to the graphs will make it evident that a large score for distance implies a relatively higher score for touches than does a small score for distance. The ratio of touches to distance becomes greater as distance increases. And this change in the ratio takes place with marked constancy throughout the graphs. It is normal for the smaller of two scores for distance to have a relatively smaller score for errors. The question to be settled in this comparison is whether a distance 84 per cent. as great as another distance normally implies 67 per cent. as many touches for the former distance as for the latter. If so, it is apparent that there is no difference between the ability of the white and the colored subjects in this test. And the following considerations indicate that such is the case.

Since the score of the negroes for distance is 84 per cent. of that of the whites, 100 may be taken to represent the actual distance score of the whites and 84 to represent the actual distance score of the negroes. Now a reference to the graphs shows that colored grades 5A and 7B, and colored girls aged 14 and 15, scored approximately 100 for distance. And the average number of touches made by these four groups of colored pupils was 40, the variation being slight. A further reference to the graphs shows that colored grade 5B, colored girls aged 11, 12 and 13, and colored boys aged 11, 13 and 15, scored approximately 84 for distance. And the average number of touches made by these seven groups of colored pupils was 28, the variation again being slight. Here we have two sets of colored pupils scoring 100 and 84, respectively, for distance, and 40 and 28 for errors. Twenty-eight is 70 per cent. of 40, and 84 is 84 per cent. of 100. Thus we have the slower set of colored pupils attaining 84 per cent. as great distance as the faster set, and making 70 per cent. as many errors. But these are approximately the figures which represent the difference between the whites and the negroes. So it seems that we can confidently conclude that there is no racial difference in ability revealed by the maze test. Wherever the negroes work as rapidly as the whites, they make approximately the same number of errors.

The graphs show no records of white subjects with as small scores as 84 for distance, and we therefore cannot ascertain the actual number of errors made by whites who worked as slowly as the assumed average of the negroes. But there is no reason for believing there would have been any appreciable racial difference if slow white records had occurred. When we compare the white groups who attained a distance of 100, the assumed average of the whites, with the colored groups who worked rapidly enough to attain this distance, we find the number of errors made by the two groups to be about the same. White grades 6A, 6B and 7A, white girls aged 14, and white boys aged 12, 13 and 14, scored approximately 100 for distance. And the average number of errors of these seven groups, the variation being small, was 44. In the preceding paragraph it was pointed out that the four colored groups who worked at this speed scored an average of 40 errors. The difference between the two sets of pupils, white and colored, is thus inconsiderable.

Finally, the reader may be referred to the white and colored columns in the graphs themselves. An inspection shows that wherever the column for the whites approaches that for the negroes in total height, representing distance, the cross-lines on the two columns, representing errors, correspondingly approach equality. And within the colored columns themselves, as within the white columns, greater total height means not only an absolutely but a relatively greater height for the cross-lines.

On the whole, while the whites were superior to the negroes in Fredericksburg in the motor ability tested, they were not superior in Richmond. Greater weight should be attached to the Richmond results on account of the larger number of subjects tested there.

Cancellation Test

The records for the cancellation test are set forth in Tables 26 and 27, and in Figures 13-15. A fairly regular increase in the scores with age may be noted.

TABLE XXVI.

CANCELLATION TEST—SCORES BY AGE AND SEX

Ages	10	11	12	13	14	15	16	17	18	19
Richmond.										
Boys—white										
Omissions Av.	..	1.0	3.2	2.8	3.2	1.6	2.0	..	..	..
A.D.	..	1.0	2.2	2.4	2.3	1.1	.6	..	..	..
Cancellations Av.	..	50.3	62.7	57.7	59.1	62.7	65.3	..	..	..
A.D.	..	6.8	11.1	12.3	8.1	8.2	3.0	..	..	..
Boys—Col.										
Omissions Av.	..	4.5	1.7	2.0	2.6	5.1	2.5	2.0	2.0	4.5
A.D.	..	5.5	1.8	1.8	2.6	4.0	1.5	2.0	1.0	1.5
Cancellations Av.	..	43.6	58.6	52.6	66.2	68.6	74.4	69.8	93.8	93.7
A.D.	..	11.6	8.6	7.1	8.1	12.8	13.7	6.4	4.5	2.2
Girls—white										
Omissions Av.	..	.8	2.5	1.8	2.9	3.5	..	..	..	..
A.D.	..	.8	2.2	1.6	1.9	1.0	..	..	..	..
Cancellations Av.	..	53.0	61.4	63.0	71.2	64.5	..	..	..	..
A.D.	..	7.5	8.8	7.4	14.7	7.5	..	..	..	..
Girls—Col.										
Omissions Av.	2.0	1.6	3.3	3.0	2.7	3.4	2.9	1.8	3.4	0.
A.D.	2.0	1.7	2.3	2.6	1.8	2.9	2.6	1.4	2.1	0.
Cancellations Av.	60.3	59.4	65.3	69.7	74.4	81.2	84.9	89.8	87.0	87.6
A.D.	2.3	11.3	11.4	9.9	13.1	13.0	11.2	8.9	8.8	10.6
Fredericksburg.										
Boys—white										
Omissions Av.	..	1.3	1.5	3.1	3.6	3.7	2.3	2.0	2.3	..
A.D.	..	1.0	1.5	1.8	2.4	3.8	2.3	2.0	1.6	..
Cancellations Av.	..	53.3	45.0	54.7	63.9	66.8	72.1	72.8	78.3	..
A.D.	..	5.0	3.0	6.7	11.4	10.2	17.0	16.5	7.0	..
Boys—Col.										
Omissions Av.	..	..	3.3	1.0	..	9.6	2.2	..	1.5	5.5
A.D.	..	..	1.6	0.	..	8.0	1.0	..	1.5	4.5
Cancellations Av.	..	..	58.6	55.5	..	70.6	76.2	..	90.0	81.2
A.D.	..	..	4.6	2.5	..	17.3	13.4	..	5.0	2.7
Girls—white										
Omissions Av.	..	..	1.5	1.5	2.2	3.3	1.8	1.0	4.0	..
A.D.	..	..	1.1	1.1	2.0	3.0	1.5	.8	4.0	..
Cancellations Av.	..	..	56.3	61.0	67.7	73.3	72.0	75.2	74.5	..
A.D.	..	..	8.0	10.3	13.2	6.3	13.0	12.6	4.5	..
Girls—Col.										
Omissions Av.	..	..	..	1.6	2.0	.6	5.5	3.2	2.0	2.5
A.D.	..	..	..	.6	1.8	.6	.5	2.0	0.	1.5
Cancellations Av.	..	..	..	68.8	63.9	66.0	94.5	84.7	81.5	70.5
A.D.	..	..	..	10.6	10.3	7.3	.5	9.7	16.5	25.5

Newport News.

Ages	10	11	12	13	14	15	16	17	18	19
Boys—white										
Omissions Av.	..	.3	1.5	1.5	1.6	4.0	..	..	..	..
A.D.	..	.3	.9	1.6	1.1	3.0	..	..	..	..
Cancellations Av.	..	67.0	53.4	59.8	63.1	56.7	..	..	..	..
A.D.	..	6.0	8.0	8.7	8.1	20.2	..	..	..	..
Boys—Col.										
Omissions Av.	..	..	0.	..	2.2	..	..	..	..	..
A.D.	..	..	0.	..	1.2	..	..	..	..	..
Cancellations Av.	..	..	49.0	..	69.5	..	..	..	..	..
A.D.	..	..	0.	..	7.0	..	..	..	..	..
Girls—white										
Omissions Av.	..	.4	2.6	2.4	2.8	3.7	2.0	..	..	..
A.D.	..	.4	2.6	2.4	2.1	2.7	2.0	..	..	..
Cancellations Av.	..	52.4	60.7	57.4	71.0	63.0	72.5	..	..	..
A.D.	..	6.0	9.8	11.3	11.7	9.5	15.5	..	..	..
Girls—Col.										
Omissions Av.	..	..	3.7	1.4	1.6	1.6	9.0	..	..	..
A.D.	..	..	3.0	.8	1.5	1.3	6.6	..	..	..
Cancellations Av.	..	..	63.4	57.4	62.6	56.3	80.3	..	..	..
A.D.	..	..	13.5	6.8	7.3	7.0	8.3	..	..	..

TABLE XXVII.

CANCELLATION TEST—SCORES BY GRADES

Richmond.

Grades	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
White											
Omissions Av.	2.6	3.0	1.5	1.7	2.5	2.1	..	..	..	..	..
A.D.	1.8	2.9	1.1	1.5	2.1	1.4	..	..	..	..	..
Cancellations Av.	61.6	55.2	54.4	65.5	62.8	66.8	..	..	..	..	..
A.D.	9.9	7.4	11.0	12.6	8.2	10.0	..	..	..	..	..
Colored											
Omissions Av.	4.0	3.4	1.4	2.8	3.7	5.5	2.9	2.2	2.6	2.4	2.1
A.D.	3.5	3.3	1.3	2.4	2.8	4.5	2.3	1.9	1.9	1.9	1.7
Cancellations Av.	60.2	58.3	63.1	65.6	81.6	74.5	77.4	82.4	89.1	86.4	87.1
A.D.	10.9	9.5	9.0	8.6	11.2	11.2	12.7	14.0	8.7	9.1	10.0

Fredericksburg.

	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
White											
Omissions Av.	..	..	2.3	..	3.3	..	2.0	1.9	..	2.6	2.3
A.D.	..	..	2.2	..	2.8	..	1.8	1.2	..	2.0	2.0
Cancellations Av.	..	..	53.0	..	62.3	..	67.0	74.9	..	72.1	74.9
A.D.	..	..	6.5	..	9.9	..	7.8	9.9	..	14.7	13.8
Colored											
Omissions Av.	..	..	3.0	..	1.7	..	2.1	4.3	..	3.3	2.2
A.D.	..	..	2.9	..	1.0	..	1.1	2.5	..	1.8	2.0
Cancellations Av.	..	..	57.7	..	79.5	..	76.4	88.3	..	82.0	78.1
A.D.	..	..	6.5	..	7.7	..	15.3	8.5	..	9.5	12.5

Newport News.

	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
White											
Omissions Av.	..	..	..	2.2	2.5	1.5	..	..	..	..	..
A.D.	..	..	..	2.1	2.5	1.2	..	..	..	..	..
Cancellations Av.	..	..	..	58.4	62.7	63.1	..	..	..	..	..
A.D.	..	..	..	11.3	9.0	13.0	..	..	..	..	..
Colored											
Omissions Av.	..	..	2.0	..	4.6	..	..	..	..	..	..
A.D.	..	..	2.0	..	3.4	..	..	..	..	..	..
Cancellations Av.	..	..	58.5	..	70.0	..	..	..	..	..	..
A.D.	..	..	9.4	..	8.8	..	..	..	..	..	..

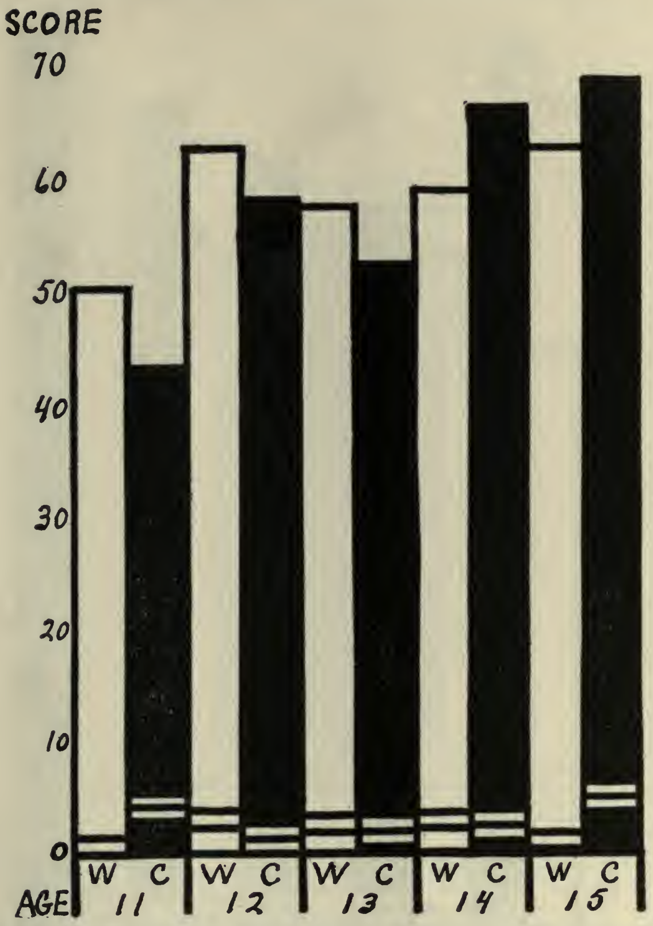

Fig. 13. Cancellation Test—Scores of White and Colored Boys—Richmond.*

*The total height of the columns indicates the score for cancellations; the height of the cross-lines indicates the score for omissions.

A reference to the graphs will show that there is no constant relation between the omissions and the cancellations, and that in all cases the omissions were very few. Only a small number of pupils, less than one-half, made any omissions at all. This accounts for the large deviations of the scores for omissions as shown in the tables mentioned, and for the very erratic behavior of these scores in the tables of ccomparison, Tables 28-32. On the whole, the negroes seem to have made

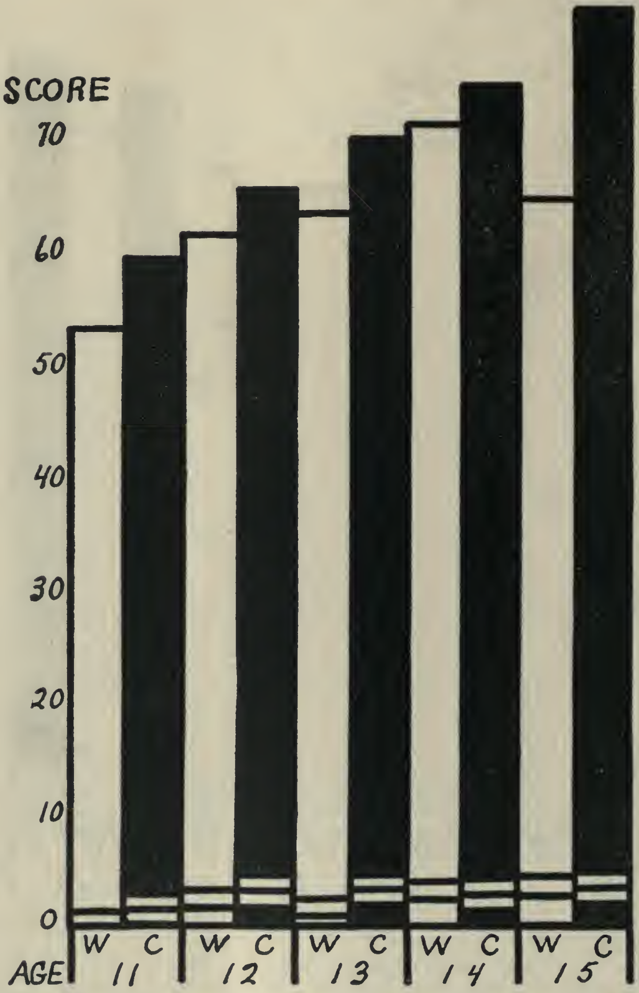

Fig. 14. Cancellation Test—Scores of White and Colored Girls—Richmond.

slightly more omissions than the whites, but the size of the probable errors indicates that this may have been a chance occurence. Certainly the negro girls, who, as will appear, are definitely superior to the white girls in cancellations, do not show as great excess in omissions as do the negro boys, and the negro boys are not superior to the white boys in cancellations at all. The omissions, therefore, will be disregarded

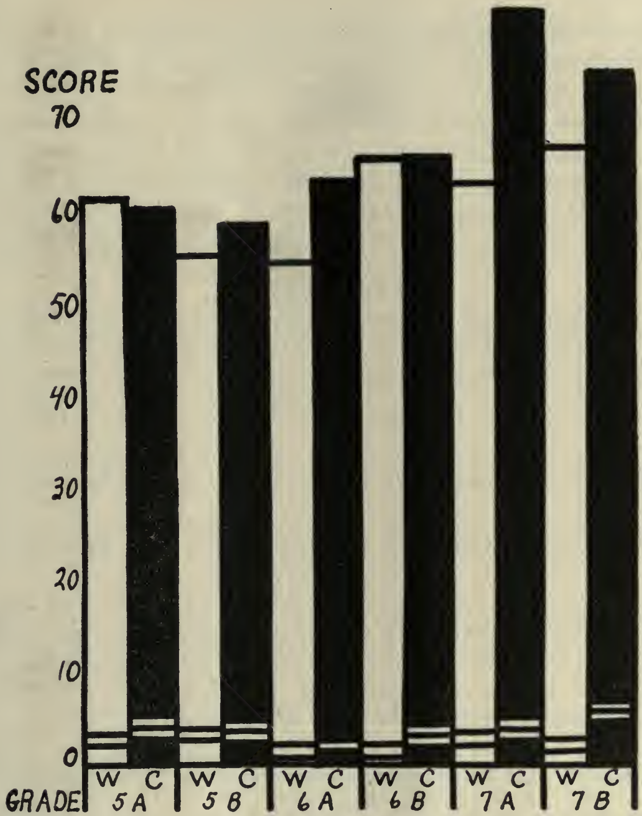

Fig. 15. Cancellation Test—Scores of White and Colored Grades—Richmond.

in the following comparisons. It may be mentioned that the peculiarity noted above in the performance of the maze test by the two races, wherein the negroes made uniformly smaller scores and thus seemed to be more careful than the whites, does not occur in the test for cancellation.

Another matter that may be remarked is that the large deviations of the scores for omission is in decided contrast with the small deviations of the cancellation scores, when the two sets of deviations are compared with the relative size of the scores themselves. That is, the so-called coefficients of variation are larger for omissions than for cancellations. A similar situation appeared in the maze test. Here the deviations of the scores for touches were as large as those of the scores for distance, while the former scores were not over one-third as large as the latter. Now both omissions and touches are measures of accuracy and both cancellations and distance are measures of speed; the two tests measure the same phenomena, one in the field of movement and the other in the field of perception and reaction. And in both tests there is greater uniformity in speed of performance than in accuracy.

TABLE XXVIII.

CANCELLATION TEST—DIFFERENCE BETWEEN SCORES OF WHITE AND COLORED SUBJECTS CLASSIFIED BY AGE AND SEX

(Minus signs indicate greater scores by the colored subjects.)

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Richmond.										
Boys										
Omissions	— 3.5	1.5	.8	.6	— 3.5	..	..	..	— .8	.8
Can'l't'ns	6.7	4.1	5.1	— 7.1	— 5.9	..	..	..	.6	2.2
Girls										
Omissions	— .8	— .8	— 1.2	.2	.1	..	..	..	— .5	.2
Can'l't'ns	— 6.4	— 3.9	— 6.7	— 3.2	—16.7	..	..	..	— 7.4	1.4
Fredericksburg.										
Boys										
Omissions	..	..	2.1	..	— 5.9	.1	..	.8	— .7	1.0
Can'l't'ns	..	..	— .8	..	— 3.8	— 4.1	..	—11.7	— 5.1	1.4
Girls										
Omissions	..	..	— .1	.2	2.7	— 3.7	— 2.2	2.0	— .2	.6
Can'l't'ns	..	..	— 7.8	3.8	7.3	—22.5	— 9.5	— 7.0	— 5.9	2.7
Newport News.										
Boys										
Omissions	..	1.5	..	— .6	..	..	..	..	.4	.6
Can'lt'ns	..	4.4	..	— 6.4	..	..	..	..	— 1.0	3.2
Girls										
Omissions	..	— 1.1	1.0	1.2	2.1	..	..	..	.8	.4
Can'l't'ns	..	— 2.7	0.	8.4	6.7	..	..	..	3.1	1.8

TABLE XXIX.

CANCELLATION TEST—DIFFERENCE BETWEEN SCORES OF WHITE AND COLORED SUBJECTS CLASSIFIED BY GRADES

(Minus signs indicate greater scores by the colored subjects.)

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E
Richmond.												
Omissions	—1.4	— .4	.1	—1.1	— 1.2	—3.4	..	..	..	..	—1.2	.3
Cancellations	1.4	—3.1	—8.7	— .1	—18.8	—7.7	..	..	..	..	—6.2	2.0
Fredericksburg.												
Omissions	..	..	— .7	..	1.6	..	— .1	— 2.4	— .7	.1	— .4	.3
Cancellations	..	..	—4.7	..	—17.2	..	—9.4	—13.4	—9.9	—3.2	—9.6	1.4
Newport News.												
Omissions	..	..	..	..	— 2.1	..	..	..	..	..	—2.1	
Cancellations	..	..	..	..	— 7.3	..	..	..	..	..	—7.3	

TABLE XXX.

CANCELLATION TEST—PERCENTAGE OF THE SCORE OF THE WHITE OBTAINED BY THE COLORED SUBJECTS, CLASSIFIED BY AGE AND SEX

Ages	11	12	13	14	15	16	17	18	Av.	P.E.
Richmond.										
Boys										
Omissions	450	53	71	81	319	..	..	..	194.8	57.2
Cancellations	87	93	91	112	109	..	..	..	98.4	3.6
Girls										
Omissions	200	132	167	93	97	..	..	..	137.8	14.1
Cancellations	112	106	111	105	126	..	..	..	112.0	2.1
Fredericksburg.										
Boys										
Omissions	..	..	32	..	259	96	..	65	113.0	30.1
Cancellations	..	..	102	..	106	106	..	115	107.2	1.5
Girls										
Omissions	..	..	107	91	18	305	320	50	148.5	38.1
Cancellations	..	..	113	94	90	131	113	109	108.3	3.8
Newport News.										
Boys										
Omissions	..	0	..	137	..	..	..	..	68.5	40.7
Cancellations	..	92	..	110	..	..	..	..	101.0	5.4
Girls										
Omissions	..	141	58	57	43	..	..	..	74.7	13.8
Cancellations	..	104	100	88	89	..	..	..	95.2	2.8

TABLE XXXI.

CANCELLATION TEST—PERCENTAGE OF THE SCORE OF THE WHITE OBTAINED BY THE COLORED SUBJECTS, CLASSIFIED BY GRADES

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Richmond.												
Omissions	154	113	93	165	148	262	..	..	..	..	155.8	13.2
Cancellations	98	106	116	100	130	111	..	..	..	..	110.2	3.0
Fredericksburg.												
Omissions	..	..	130	..	52	..	105	226	127	96	122.7	13.2
Cancellations	..	..	109	..	128	..	114	118	114	104	114.5	1.9
Newport News.												
Omissions	..	..	..	..	184	..	..	..	..	..	184.0	..
Cancellations	..	..	..	..	112	..	..	..	..	..	112.0	..

TABLE XXXII.

CANCELLATION TEST—PERCENTAGE OF COLORED SUBJECTS REACHING OR EXCEEDING THE AVERAGE OF THE WHITE, BY AGE AND SEX AND BY GRADES

Richmond.

Ages	11	12	13	14	15		Av.	P.E.
Boys								
Cancellations	33	31	37	78	60	..	47.8	6.4
Girls								
Cancellations	67	59	74	60	81	..	68.2	2.8
Grades	5A	5B	6A	6B	7A	7B		
Cancellations	49	63	80	55	89	67	67.2	3.8

In explanation of this it may be suggested that individuals differ in their attitude toward the tests as well as in their ability to perform them. Of course those who emphasize speed will neglect accuracy and those who emphasize accuracy will neglect speed. These matters will normally adjust themselves among a large number of subjects, and the final scores for accuracy and speed will not be affected. But with reference to approximating the average score it may be that speed of reaction will more readily take care of itself than will accuracy in a normal performance of a test. At the start, subjects are set to attempt a performance that will be in large measure speedy, and at least a reasonable degree of speed is put forth by all. Accuracy, however, requires more constant care on the part of the performer; neglect of accuracy is not so apparent to him while he is reacting—he may not notice the omitted letter or the touch. It is more difficult to gauge and to control accuracy than speed. And so, unless there is a very careful adjustment of attitude toward accuracy by all subjects, it will vary considerably, while speed will vary to a less degree. Consequently a greater deviation for accuracy than for speed is to be expected in tests involving both factors.

The tables which make the comparisons between whites and negroes in cancellation show the following facts: In Richmond, the colored boys obtained 98.4 per cent. of the score of the white boys. The colored girls obtained 112.0 per cent. of the score of the white girls. And when classified by grades—the grades contain a larger proportion of girls than of boys—the colored pupils obtained 110.2 per cent. of the score of the white pupils. This inferiority of colored to white boys may be disregarded, since it falls within the range of the probable error. It may be said that the boys of the two races did about equally well. But the colored girls and the colored grades are clearly superior to the white girls and grades, the probable errors in these cases being sufficiently small for reliability.

In Fredericksburg, the colored boys, girls and grades are all definitely superior to the white. In Newport News, a very slight superiority is shown by the colored boys, but this may be discounted as was the inferiority of the colored boys in Richmond. The colored girls seem to be inferior here, but this is not well established when considered in connection with the probable error. The grade comparison is considerably in favor of the colored pupils, but it is based upon figures from only one grade of each race.

The percentages of colored subjects reaching or exceeding the average of the white, in Richmond, are as follows: Boys, 47.8; Girls, 68.2; Grades, 67.2. As in the former comparison for Richmond, the size of the probable errors renders it unsafe to say there was any real difference between the boys of the two races; but the colored girls and grades are undoubtedly superior.

Taken all together, the figures show that the colored girls are superior to the white girls in the traits measured by this test, and that the colored boys are not appreciably inferior to the white boys. This sex difference between the races is interesting, but no satisfactory explanation of it suggests itself. It is confirmed by Pyle ('15), in the study previously mentioned. From the figures which he gives it may be calculated that in the "A Test"—the cancellation test used here—the colored boys tested by him obtained 98.4 per cent. of the score of the white boys and the colored girls obtained 108.2 per cent. of the score of the white girls. These are almost identical with the figures found herein.

In this connection it may be said that no other constant or reliable racial sex difference in ability is indicated by this study. The scores of the boys of both races were generally, though not always, slightly lower than the scores of the girls, as is usually the case in psychological tests. And on the whole there is a slightly smaller difference between the white and negro girls than between the white and negro boys, but this is not at all invariably true. Pyle states, as quoted in Chapter I, that in the tests which he employed the girls of the two races stood nearer together than did the boys.

CHAPTER IV

COMPARISON OF SUB-CLASSES OF NEGROES

The terms negro and colored have been used interchangeably in this study, (except in the tables and the graphs), and they are generally so used. But it is obvious that such usage is justified only by convenience and not by fact. The so-called negroes of the United States are negroes only in part; in large measure they are people of mixed blood, and the intermixture has been almost entirely with the white race. There are all degrees of intermixture, ranging from almost pure negro to almost pure white. "Mulatto" is the term generally employed to describe persons of this mixed stock. But here again the usage is justified only by convenience, since a mulatto, strictly speaking, is the offspring of the union of a pure white and a pure negro. The terms quadroon, meaning the child of a mulatto and a white, and consequently three parts white and one part negro; and octoroon, meaning a child of a white and a quadroon, seven parts white and one part negro, are fairly common. But there is no recognized term to describe the racial status of the offspring of a pure negro and a mulatto, who is three parts negro and one part white. "Sambo" has been suggested for this purpose, but the popular connotation of the word is not such as to convey the desired meaning. And there are no widely accepted terms to describe other degrees of race admixture. The need for them has not been felt.

The relative number of pure negroes and persons of part negro blood in this country is not accurately known. The Federal Census has made an attempt to determine this, and its figures are the most reliable that we have. The negroes were classified as black and mulatto. But as stated in the census report ('10, p. 79): "Considerable uncertainty necessarily attaches to this classification, however, since the accuracy of the distinction made depends largely upon the judgment and care of the enumerators. Moreover, the fact that the definition of the term 'mulatto' adopted at different censuses has not been entirely uniform may affect the comparability of the figures in some degree. In 1870, as in 1910, however, the term was applied to all persons having any perceptible trace of negro blood, excepting, of course, negroes of pure blood." The census shows that in 1910, 79 per cent. of the negro population of the country was black and 21 per cent. mulatto—roughly speaking, there were about eight million blacks and two million mulattoes. In Virginia, the negro population was 67 per cent. black and 33 per cent. mulatto. In Richmond, the percentages of blacks and mulattoes were 60 and 40, respectively.

The percentage of mulattoes is generally higher in the cities than in the rural districts. In Virginia, the five cities with a population of 25,000 or over have an average of 43 per cent. of mulattoes in their negro populations. This figure, when compared with the mulatto population of the state, is fairly typical of the larger proportion of mulattoes in the cities of the country at large.

The percentage of mulattoes is also in general considerably higher in the North than in the South. The states with the largest negro populations have the largest percentage of pure negroes, though there are exceptions to this relation. South Carolina, Alabama and Georgia, for example, have negro populations of 55.2, 42.5 and 45.1 per cent., respectively. And the percentages of mulattoes among the negroes of these states are 16.1, 16.7 and 17.3, respectively. In Illinois, Pennsylvania and Massachusetts, the negroes are 1.9, 2.5 and 1.1 per cent. of the total populations. And in these states the percentages of mulattoes are 33.8, 19.2 and 36.7. States with negro populations intermediate between the two groups mentioned are Kentucky, Tennessee and Maryland, which have in their respective populations 11.4, 21.7 and 17.9 per cent. of negroes. And here the percentages of mulattoes are respectively 25.2, 25.1 and 18.6. On the whole, there are larger percentages of mulattoes among the negroes in states with small negro populations, and there are larger percentages in the cities than in the country districts.

What these facts indicate it is difficult to say. They may mean that mulattoes are more attracted than are pure negroes by the reputed advantages held out to colored people in the North, and by the reputed opportunities of city life. If so, it would seem that mulattoes have greater capacity for perceiving opportunity and greater ambition to take advantage of it. Or color distinctions among the negroes themselves may influence those of lighter skin to seek to relieve the circumpressure of the bulk of their race by Northern and urban migration. Or the non-agricultural industries in which negroes are engaged in the North and in the cities may possibly select mulattoes in preference to blacks, either because of their lighter color or because of their greater ability, or for both reasons. Or it may be that there is greater race intermixture in the North and in the cities than in the rural districts and the South. All four of these factors may operate. The census shows that there has been taking place a migration of negroes from the country to the city, and from the South to the North—particularly to the cities of the North. And it is in these centers of migration that the proportion of mulattoes is highest. Several observers, (see Stone ,'08, p. 401, ff.), have reported the apparent growth of a class distinction between mulattoes and pure blacks, tending to separate them, especially in the cities. The occupations in which negroes are employed in the cities and in the North have increased and become more standardized in recent years, and intelligence and light color are both probably more in demand in such occupations than in the more simple and isolated labor of rural life. And the life of the so-called underworld of cities, and the fact that inter-racial marriages are permitted in the North, would probably tend to increase the percentage of mulattoes in these places. So while the causes of the distribution of mulattoes cannot be definitely stated, it would seem that those mentioned above may reasonably be included among them.

It is further worthy of note, that according to the census figures the relative number of mulattoes is increasing. The years in which they were separately classified were 1850, 1860, 1870, 1890 and 1910. And the percentages of mulattoes in the country at large were as follows in those years: 11.2, 13.2, 12.0, 15.2 and 20.9. But this does not mean, as is often supposed, that intermixture of whites and negroes has increasingly taken place in accordance with these percentages. The relative increase in the number of persons of mixed blood may have been due to marriage among colored people themthemselves, after a certain degree of racial admixture had occurred, without an increase, or even a continuance, of direct crossing between negroes and whites. For the mulattoes and the pure negroes marry each other, and this reduces the original percentage of pure negroes among the total offspring, and increases the percentage of persons of mixed blood. Of course, in the long run, unless there were a new infusion from white stock, the amount of white blood would become very small in any individual. But within the years covered by the census reports there would be enough traces of the white left to cause the individuals possessing them to be classified as having some white characteristics, and the basis of the census classification is the possession of any perceptible trace of white blood. This consideration renders the increase of racial intermixture as indicated by the census figures undoubtedly too high, even if the accuracy of the figures be granted.

Views of Other Writers

The presence of the mulatto element among the colored population has been taken into account by a number of writers who have dealt with the negro, although it has been neglected by a number of others. In Chapter I was quoted a statement from Strong ('13) to the effect that she divided the negroes tested by her into three classes on the basis of the color of their skin, and found that those of lightest color varied most from the normal, both above and below. Mayo ('13) was aware that the presence of mulattoes might have influenced the school records of the negroes in his study. Pyle ('15) suggested that the superior negroes in his groups might have had a greater proportion of white blood. And Bean ('06) recognized that the brains which he investigated were partly those of mulattoes. Statements from other writers may be given to indicate the attitude of those who have considered the matter from various standpoints.

Boas, in concluding a discussion of the American negro problem, writes: "It appears....that the most important practical questions relating to the negro problem have reference to the mulattoes and other mixed bloods—to their physical types, their mental and moral qualities, and their vitality. When the bulky literature of this subject is carefully sifted, little remains that will endure serious criticism; and I do not believe that I claim too much when I say that the whole work on this subject remains to be done. The development of modern methods of research makes it certain that by careful inquiry definite answers to our problems may be found. Is it not, then, our plain duty to inform ourselves, that, so far as that can be done, deliberate consideration of observations may take the place of heated discussion of beliefs in matters that concern not only uorselves, but also the welfare of millions of negroes?" (11, pp. 277-278).

Stanley Hall says: "The chief event in the history of the Southern negro in the new world is the infiltration of white blood. But for this the negro in mind and body would be so distinct from us that all our problems connected with the race would be vastly simplified. Just how far he has lost his rare racial homogeneity here it is impossible to tell. The extreme minimal estimate that I have found is that one-tenth have some white blood, and one maximal estimate is that two-thirds are partly white. Page thinks that from one-ninth to one-sixth are mixed. DuBois says that two million negroes have some white blood. Most estimates range somewhere between one-fifth and one-half. .... Moreover, the grade of pigmentation is not a sure index of the degree of miscegenation, and in the veins of some thought purely African probably flows at least a little of the best white blood of the land. .... Thus all the vast psychophysic differences between the two races are bridged, and they possibly fuse with each other by all imperceptible gradations....At any rate, men like Fred Douglas, Bishop Payne, Booker Washington, Du Bois Chestnut, Tanner, Dunbar, Thomas and a score of others, are not typical negroes." ('05, pp. 360-361).

In a discussion of the general status of the mulatto as compared with the pure negro, Jordan ('13) contends that the former is considerably superior to the latter. The pure negro is claimed to be capable of only the rudiments of civilization. His powers of attention and reflection are poor. He can draw general conclusions from particular cases only with difficulty, he is imitative rather than creative, he lacks foresight, he has small power of profiting by observation, his character is mobile, and he is guided largely by the instinct of the moment. "The negro cannot undergo mental development beyond a certain definite maximum. The curious thing is that no attempt is made to establish this opinion on a scientific basis and to definitely determine the limit of mental development beyond which the law of diminishing returns dictates cessation of effort; and furthermore that in flat contradiction to this common opinion education is planned in apparent utter disregard of it." ('13, pp. 578-579). But with the mulatto the case is different. "Where negro, mulatto and white are jointly concerned the teachers are unequivocal in their opinion that mental alertness and the development of the higher psychical activities corresponds in degree quite uniformly with the amount of 'white' blood as judged by color of the skin." ('13, p. 577). It is true, argues Jordan, that many mulattoes are inferior, but this is because they come from inferior parents. The way to uplift the negro race is by the proper selection and breeding of mulattoes.

A view very different from this is held by Le Bon. He writes: "Doubtless very different races, the black and the white for example, may fuse, but the half-breeds that result constitute a population very inferior to those of which it is sprung, and utterly incapable of creating or even of continuing, a civilization. The influence of contrary heredities saps their morality and character. When half-breeds, the offspring of white men and negroes, have chanced to inherit a superior civilization, as in Saint Domingo, this civilization has speedily been overtaken by the most lamentable degeneration. Cross-breeding may be a source of improvement when it occurs between superior and sufficiently allied races, such as the English and the Germans in America, but it always constitutes an element of degeneration when the races, even though superior, are too different." ('98, pp. 52-53). Le Bon quotes Agassiz to the effect that Brazil is undergoing degeneration on account of the large number of half-breeds in the population, cross-breeding being fatal to the best qualities of whites, blacks and Indians, the peoples concerned. It should be said that this view of Le Bon's is held by only a small minority of those who have discussed the question.

Baker's opinion ('08) concerning the relative capacity of the mulatto and the pure negro does not seem to be very decided one way or the other. He points out that a number of leading negroes, as Washington, Du Bois, Douglass, Chestnutt, Braithwaite, Tanner and Terrell are mulattoes. Indeed, "Most of the leading men of the race to-day in every line of activity are mulattoes." ('08, p. 173). But on the other hand, such negro leaders as Vernon, Miller, Dunbar, Price and Mason are probably pure-blooded. He claims that to be a mulatto is to be neither a negro nor a white, but is to have the ambitions and hopes of both races. Mulattoes and negroes keep together on account of social pressure from the whites. As to the number of mulattoes, Baker writes: "From my own observation and from talking and corresponding with many men who have had superior opportunities for investigation, I think it safe to say that between one-fourth and one-third of the Negroes in this country at the present time have a visible mixture of white blood.....It is probable that 3,000,000 persons out of the 10,000,000 population are visibly mulattoes." ('08, p. 153). The proportion of mulattoes is stated to be much larger in the North than in the South, and the census figures are mentioned as being unreliable.

In a discussion of the political status of the negro, Stone ('08) argues that a distinction should be drawn between the pure negro and the mulatto. "There can no longer be a question as to the superior intelligence of the mulatto over the Negro—of his higher average potential capacity." ('08, p. 401). The leaders of the colored race, says Stone, have been mulattoes, and this has been true in such places as Jamaica, Santo Domingo, Haiti, South Africa and Liberia, as well as in the United States. The exceptional blacks of pure blood who have attained prominence were generally not descended from true negroes at all. Their ancestry is to be found in those stocks, such as the Fulah and others of high type, that were brought from Africa as slaves in small numbers along with the mass of true negroes.

From these abstracts it is evident that there is very little definitely known as to the relative merits of pure negroes and mulattoes. Of opinion, based more or less closely upon observation, there is a great deal. But there has been no serious attempt made to attack the problem from an experimental or scientific standpoint. The views of men are uncertain as to the relative abilities of whites and negroes; it is to be expected that they will be much more uncertain when they deal with sub-classes within the colored group.

The Classification

In the present investigation the negroes tested were divided into four classes on the basis of racial purity as indicated by color of skin, hair texture and general facial and cranial conformation, the main emphasis being placed upon color. The four classes were pure negroes, negroes three-fourths pure, mulattoes proper, and quadroons. Of course there were probably included in the classification some negroes who did not belong, strictly speaking, in any of these classes. A few octoroons, for example, may have been present, or a few persons who were of seven-eighths pure negro stock. Such cases were placed in the class which seemed to fit their status best, and it is not thought that any constant error resulted from this procedure.

It is also probable that errors were made in the classification. Certain individuals may have been placed in a class too near the pure negroes or too near the pure whites. But here again the incorrect classifications would tend to balance each other, and it is improbable that a constant error in any direction resulted. The effect of the overlapping of the classes would be to lessen the differences found between them.* Consequently it follows that in so far as the classification was inaccurate, the real differences were greater than those indicated by the scores.

In setting forth the results of the tests, the four classes mentioned are adhered to. But in order to make the classification still less subject to error, and to secure a larger number of subjects in each class, the pure and the three-fourths pure negroes are grouped together, and the mulattoes and the quadroons are grouped together, and the results are given separately in all cases for the two resulting classes as well as for the original four. The difference in amount of white blood between these two classes is greater than that between any two classes of the four-class division, and the difference between the scores of the combined pure and three-fourths negroes and the combined mulattoes and quadroons should be correspondingly greater than that between the classes of the original division. This we shall find to be the case. And it should be noted in this connection that the class composed of mulattoes and quadroons is very predominantly mulatto, since the quadroons were few in number. This fact obviously makes the difference found between mulattoes and quadroons combined and pure and three-fourths negroes combined less than it really is.

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*It seems to the writer that probably the greatest chance for erroneous classification occurred between the pure negroes and the negroes three-fourths pure. It is not unlikely that differences in color between various stocks of pure negroes may have caused some comparatively light-colored individuals of this class to be counted as three-fourths pure; and some three-fourths pure individuals of unusually dark native stock may have been classed as pure-blooded. This supposition is borne out by the fact that the differences revealed by the tests between the pure and the three-fourths pure negroes were less than the differences between the other classes.

It should be said that the classification of the negroes was made by the writer, who had had considerable experience with negroes, at the time the tests were administered. None of the subjects was previously known to him, and he is aware of no circumstance that could have influenced the classification in addition to the basis previously adopted. The subjects seemed to fit into the various classes both naturally and easily, and doubt as to the correctness of a classification was so infrequent as to be negligible.

Numbers and Ages

The negroes tested in Fredericksburg and Newport News were so few that the results from those cities were not used in this intra-racial study. There was not a sufficient number of each of the four classes in either city to enable results to be computed for any year or any grade. As in the general comparison between whites and negroes, results from only one subject were not considered.

The 319 negroes tested in Richmond fell into the different classes numerically as shown in Tables 33 and 34, which give the numbers by age and sex and by grades. The three highest and the two lowest years are not used in the comparisons on account of the small number of pupils in them. It may be noted that the largest class is composed of mulattoes, the smallest of quadroons, and that the classes of pure negroes and three-fourths pure negroes are of about equal size. The mulattoes and quadroons together constitute 52 per cent. of the total; the pure and three-fourths negroes together constitute 48 per cent. of the total. In the elementary school the mulattoes and quadroons are 46 per cent. of the total number; in the high school the mulattoes and quadroons are 59 per cent. of the total number. There is thus a larger proportion of light-colored negroes in the high school than in the elementary school. And in the grades tested as a whole there is a larger percentage of negroes of mixed blood than there is in the city at large, as shown by the census figures.

These facts as to the relative numbers of pure and mixed bloods in the school system indicate that the schools select colored persons of partly white lineage to a greater extent than they select pure negroes, and that as the grades advance the selection becomes more pronounced. This would imply that mulattoes in general are of greater ability and ambition than are pure negroes. And the fact that there is a larger proportion of light-colored negroes in the high school than in the elementary school would partly explain the relatively greater ability of high school negroes that was found in the general comparison between white and colored subjects. Mixed bloods, as will be shown, are of greater ability, and there are proportionately more of them in the upper grades.

TABLE XXXIII.

NUMBER OF COLORED SUBJECTS—RICHMOND—CLASSIFIED BY RACIAL PURITY, AGE AND SEX

Ages	10	11	12	13	14	15	16	17	18	19	21	Totals
Boys												
Pure	..	1	4	8	7	4	4	4	2	2	..	36
Three-Fourths	1	3	2	3	5	4	2	3	1	1	..	25
Mulattoes	..	1	8	7	4	7	8	2	3	1	..	41
Quadroons	..	1	..	1	2	1	..	..	..	..	..	5
Girls												
Pure	..	1	4	5	10	8	2	7	1	..	..	38
Three-Fourths	1	1	10	9	14	6	7	2	4	1	..	55
Mulattoes	2	4	8	16	12	11	19	10	6	1	1	90
Quadroons	..	3	..	4	6	2	5	4	4	1	..	29
Boys												
Pure and Three-Fourths	1	4	6	11	12	8	6	7	3	3	..	61
Mulattoes and Quadroons	..	2	8	8	6	8	8	2	3	1	..	46
Girls												
Pure and Three-Fourths	1	2	14	14	24	14	9	9	5	1	..	93
Mulattoes and Quadroons	2	7	8	20	18	13	24	14	10	2	1	119

TABLE XXXIV.

NUMBER OF COLORED SUBJECTS—RICHMOND—CLASSIFIED BY RACIAL PURITY AND GRADES

Grades	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A	Totals
Pure	10	10	11	5	5	4	12	5	2	3	7	74
Three-Fourths	10	13	10	5	7	5	9	9	5	4	3	80
Mulattoes	20	13	11	9	7	9	14	13	11	12	12	131
Quadroons	2	2	3	3	..	1	7	4	3	6	3	34
Pure and Three-Fourths	20	23	21	10	12	9	21	14	7	7	10	154
Mulattoes and Quadroons	22	15	14	12	7	10	21	17	14	18	15	165

The ages of the different classes of negroes in the various grades are given in Table 35, and the differences between the age of each class and the age of white pupils of the same grade—the white pupils in question being those tested in Richmond—are given in Table 36. This latter table shows that the pure negroes were .69 of a year older than the white pupils; the three-fourths pure negroes were .32 of a year older; the mulattoes were .29 of a year older; and the quadroons were .07 of a year younger. The pure and three-fourths negroes combined were .51 of a year older than the whites; the mulattoes and quadroons combined were .23 of a year older. These figures are significant. They show that the darker negroes were slower in reaching a given grade than were those of lighter color. The differences are small, and are subject to variation from grade to grade. But the average differences, which are here quoted, are uniformly greater for the darker negroes, and the probable errors are not large enough to invalidate the significance of this uniformity.

TABLE XXXV.

AGES OF THE COLORED SUBJECTS—RICHMOND—CLASSIFIED BY RACIAL PURITY AND GRADES

Grades		5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
Pure	Av.	12.7	13.2	12.8	14.2	14.8	14.7	15.4	17.0	16.5	16.0	17.8
	A.D.	.9	.6	.6	.3	.3	.7	.8	.4	.5	1.3	.7
Three-Fourths	Av.	11.7	13.1	13.0	13.4	13.7	14.4	14.3	16.6	16.6	17.7	17.0
	A.D.	1.0	1.0	.8	1.5	.6	.6	.6	.6	1.1	.9	1.3
Mulattoes	Av.	12.6	12.4	12.8	13.2	13.8	14.6	15.2	15.8	16.5	16.6	17.6
	A.D.	1.1	.9	.6	.8	1.3	.8	.5	.8	1.0	.5	1.2
Quadroons	Av.	12.0	12.0	11.6	14.0	..	..	14.0	16.0	16.6	17.0	17.6
	A.D.	1.0	1.0	.9	0.	..	..	.3	1.0	.9	.7	.9
Pure and Three-Fourths	**Av.**	12.2	13.1	12.9	13.8	14.1	14.5	14.9	16.7	16.5	17.0	17.6
	A.D.	1.0	.8	.7	.9	.7	.7	.8	.6	.9	1.1	.9
Mulattoes and Quadroons	Av.	12.5	12.4	12.5	13.4	13.8	14.5	14.8	15.8	16.5	16.7	17.6
	A.D.	1.1	.9	.9	.8	1.3	.9	.7	.9	1.0	.6	1.2

TABLE XXXVI.

AGES—DIFFERENCE IN YEARS BETWEEN THE WHITE AND EACH OF THE FOUR CLASSES OF COLORED SUBJECTS TESTED—RICHMOND

(Minus signs indicate that the colored subjects are of greater age.)

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Pure Negroes	—.3	—.7	.6	—1.0	—1.5	—1.1	—1.0	—1.6	.5	— .8	—.69	.15
Three-Fourths	.7	—.6	.4	— .2	— .4	.8	.1	—1.2	—1.2	0	—.32	.14
Mulattoes	—.2	.1	.6	0	— .5	—1.0	— .8	— .4	— .1	— .6	—.29	.10

	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Quadroons	.4	.5	1.8	—.8	..	..	.4	—.6	—.5	—.6	.07	.21
Pure and Three-Fourths	.2	—.6	.5	—.6	—.8	—.9	—.5	—1.3	—.5	—.6	—.51	.09
Mulattoes and Quadroons	—.1	.1	.9	—2	—.5	—.9	—.4	—.4	—.2	—.6	—.23	.09

Standing in the Tests

The tests used in this comparison are the mixed relations, Tests I and II, and the completion. These tests revealed marked differences between whites and negroes as a whole, and they are therefore well adapted to bring out any differences that may exist between the various classes of negroes. The maze and cancellation tests did not show any considerable differences in the general inter-racial comparison, and they are consequently not employed here.

In setting forth the results of the tests the same order is followed as in the preceding chapter. In the case of each test, first are given the actual scores, with their average deviations, classified by age and sex and by grades. Then appear graphs based upon these scores. The graphs are drawn only for the two-division classification—that of pure and three-fourths negroes combined and mulattoes and quadroons combined. The scores of the white pupils tested in Richmond are included in the graphs for the sake of comparison. Following the graphs are the tables in which the comparisons are made. In each instance the score of the colored subjects is compared with that of the corresponding white pupils. The actual differences between the scores are given; the percentage of the score of the whites that was obtained by the negroes next appears; and lastly are shown the percentages of the two-division classification that reach or exceed the average score of the whites. The averages of the various ages and grades, with their probable errors, appear in each table of comparison.

Tables 37 and 38 give the scores in the mixed relations test. Figures 16-21 present these scores in graphic form. Tables 39-43 make the comparisons. From these latter tables the following facts appear.

TABLE XXXVII.

MIXED RELATIONS TEST—SCORES OF COLORED SUBJECTS—RICHMOND—CLASSIFIED BY RACIAL PURITY, AGE AND SEX

Ages	10	11	12	13	14	15	16	17	18	19
Test I.										
Boys—Pure										
Av.	..	..	6.5	12.3	9.7	10.5	19.3	18.7	20.0	16.5
A.D.	..	..	1.0	4.1	3.2	1.5	8.3	5.2	4.0	10.5
Boys—Three-Fourths										
Av.	..	9.0	9.0	17.0	18.5	6.5	21.0	19.3	..	..
A.D.	..	2.6	1.0	6.0	5.5	2.5	0.	10.3	..	..
Boys—Mulattoes										
Av.	..	..	12.5	7.4	12.5	17.2	21.0	32.5	19.6	..
A.D.	..	..	6.0	3.5	4.5	8.5	9.5	2.5	12.6	..
Boys—Quadroons										
Av.	..	..	..	..	28.0	..	..	..	..	..
A.D.	..	..	..	..	0.	..	..	..	..	..
Girls—Pure										
Av.	..	..	9.6	10.5	12.6	15.1	17.0	21.4	..	..
A.D.	..	..	4.0	6.0	4.4	7.5	5.0	6.1	..	..
Girls—Three-Fourths										
Av.	..	..	9.8	10.6	11.4	20.8	23.4	16.0	16.5	..
A.D.	..	..	4.6	3.7	6.1	7.8	6.7	4.0	6.0	..
Girls—Mulattoes										
Av.	9.5	12.0	12.5	14.6	15.7	18.1	20.1	29.5	14.8	..
A.D.	7.5	3.0	6.1	6.9	9.9	9.4	7.2	4.7	6.5	..
Girls—Quadroons										
Av.	..	9.6	..	10.7	23.0	20.0	23.4	30.7	25.2	..
A.D.	..	5.3	..	7.2	8.3	12.0	6.4	4.2	9.7	..
Test II.										
Boys—Pure										
Av.	..	..	7.7	13.0	12.8	18.0	24.0	26.5	36.5	28.5
A.D.	..	..	2.7	3.5	8.8	7.0	7.0	10.5	1.5	.5
Boys—Three-Fourths										
Av.	..	11.3	9.0	17.3	18.8	4.5	22.0	33.3	..	..
A.D.	..	7.0	0.	7.0	10.8	1.5	7.0	3.0	..	..
Boys—Mulattoes										
Av.	..	..	14.0	9.8	15.0	27.5	24.5	39.5	27.6	..
A.D.	..	..	8.2	3.4	8.0	7.1	10.0	.5	8.0	..
Boys—Quadroons										
Av.	..	..	..	..	25.5	..	..	..	..	..
A.D.	..	..	..	..	13.5	..	..	..	..	..
Girls—Pure										
Av.	..	..	9.0	8.2	13.7	19.8	28.5	26.8	..	..
A.D.	..	..	3.3	2.2	7.5	8.8	7.5	9.7	..	..
Girls—Three-Fourths										
Av.	..	..	9.8	15.2	11.2	26.3	29.7	22.0	20.2	..
A.D.	..	..	4.8	6.6	7.5	7.3	6.7	4.0	5.2	..
Girls—Mulattoes										
Av.	13.0	14.0	12.1	11.6	20.5	20.6	26.4	35.3	19.8	..
A.D.	5.0	5.0	5.3	7.6	12.2	10.0	6.6	3.7	10.8	..
Girls—Quadroons										
Av.	..	15.5	..	8.6	24.6	27.0	30.8	37.5	30.7	..
A.D.	..	3.5	..	4.6	12.6	10.0	5.2	1.0	8.2	..
Test I.										
Boys—Pure and Three-Fourths										
Av.	..	10.5	7.3	13.6	12.9	7.8	19.7	19.0	20.3	16.5
A.D.	..	3.5	1.3	4.2	6.0	2.8	6.7	7.4	3.0	10.5
Boys—Mulattoes and Quadroons										
Av.	..	13.5	12.5	9.5	15.6	17.2	21.0	32.5	19.6	..
A.D.	..	4.5	6.0	4.7	7.4	8.5	9.5	2.5	12.6	..
Girls—Pure and Three-Fourths										

Ages	10	11	12	13	14	15	16	17	18	19
Av.	..	17.5	9.7	10.6	11.9	18.0	22.0	20.2	17.2	..
A.D.	..	3.5	4.3	4.4	5.3	8.3	6.2	5.5	5.4	..
Girls—Mulattoes and Quadroons										
Av.	9.5	11.0	12.5	13.7	18.1	18.4	20.8	29.8	19.0	29.5
A.D.	7.5	4.2	6.1	7.2	9.9	9.8	6.9	4.7	10.0	.5
Test II.										
Boys—Pure and Three-Fourths										
Av.	..	12.0	8.0	14.1	15.3	11.2	23.3	29.8	36.6	32.0
A.D.	..	6.0	2.8	4.7	10.0	7.5	7.0	8.2	1.3	4.6
Boys—Mulattoes and Quadroons										
Av.	..	14.0	14.0	13.2	18.5	28.4	24.5	39.5	27.6	..
A.D.	..	12.0	8.2	7.2	10.8	7.0	10.0	.5	8.0	..
Girls—Pure and Three-Fourths										
Av.	..	25.5	9.6	12.7	12.2	22.6	29.4	25.7	19.8	..
A.D.	..	.5	4.5	5.8	7.7	8.0	6.8	8.5	4.8	..
Girls—Mulattoes and Quadroons										
Av.	13.0	14.5	12.1	11.1	21.9	21.6	27.3	35.9	24.2	28.0

3.3 11.0 0. A.D. 5.0 4.5 5.3 7.3 10.0 10.1 6.6

TABLE XXXVIII.

MIXED RELATIONS TEST—SCORES OF COLORED SUBJECTS—RICHMOND—CLASSIFIED BY RACIAL PURITY AND GRADES

Grades	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
Test I.											
Pure											
Av.	7.6	10.5	12.4	12.2	13.3	11.7	18.4	17.4	21.0	28.6	17.5
A.D.	2.6	3.8	4.2	3.7	4.3	5.2	7.7	4.4	1.0	3.3	6.5
Three-Fourths											
Av.	9.3	8.6	13.6	17.0	8.7	13.4	17.7	20.0	22.0	22.0	22.3
A.D.	3.5	1.6	5.6	4.0	5.5	6.4	4.1	7.1	7.6	6.6	10.3
Mulattoes											
Av.	9.8	12.3	13.1	12.8	9.0	11.6	23.2	22.0	16.4	30.0	24.0
A.D.	3.9	4.7	7.6	6.4	4.0	5.5	6.5	9.8	6.0	3.9	10.3
Quadroons											
Av.	4.5	9.0	12.3	13.0	..	..	27.3	22.2	13.3	32.1	29.6
A.D.	2.5	1.0	7.0	2.0	..	..	4.6	8.2	5.0	3.1	4.6
Test II.											
Pure											
Av.	8.7	9.8	12.5	15.2	18.2	11.5	22.5	28.4	26.0	35.0	28.4
A.D.	4.5	4.8	4.5	4.2	7.8	5.0	10.0	4.4	10.0	1.3	7.5
Three-Fourths											
Av.	12.6	8.9	12.1	16.0	14.4	10.6	24.6	27.2	29.0	34.2	24.3
A.D.	6.8	4.5	6.1	8.8	7.5	6.6	8.4	7.5	6.4	4.7	9.6
Mulattoes											
Av.	9.1	12.1	15.7	14.0	17.4	13.4	28.6	28.3	21.8	35.6	30.5
A.D.	4.2	7.6	8.1	8.2	7.2	7.1	6.6	7.3	7.1	2.8	8.6
Quadroons											
Av.	4.0	9.0	22.5	8.0	..	..	35.1	29.7	23.0	36.1	34.6
A.D.	0.	3.0	3.5	2.6	..	..	2.4	6.7	8.0	1.5	4.6
Test I.											
Pure and Three-Fourths											
Av.	8.4	9.4	13.0	14.2	10.1	12.6	18.1	19.0	21.7	25.3	19.0
A.D.	3.0	2.7	4.9	4.0	5.9	6.0	5.8	5.9	5.5	5.6	8.0
Mulattoes and Quadroons											
Av.	9.3	11.8	13.0	12.9	9.0	13.1	24.5	22.0	15.7	30.7	25.1
A.D.	3.9	4.0	7.4	5.6	4.0	6.9	6.3	9.4	5.7	3.6	9.4
Test II.											
Pure and Three-Fourths											

Grades	5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
Av.	10.5	9.3	12.3	15.6	16.0	11.0	23.4	27.6	28.1	34.5	27.2
A.D.	5.5	4.8	5.2	6.4	8.0	6.2	9.3	6.6	7.5	3.4	8.4
Mulattoes and Quadroons											
Av.	8.9	11.7	16.7	12.5	17.4	13.7	30.8	28.6	22.0	35.8	31.3
A.D.	4.1	6.8	8.0	7.0	7.2	6.7	5.7	7.3	7.3	2.5	7.9

In Test I, in the case of boys, classified by age, the pure negroes obtained 58.8 per cent. of the score of the whites; the three-fourths pure negroes obtained 72.2 per cent. of the score of the whites; and the mulattoes obtained 78.5 per cent. of the white score.* When the boys are grouped into two classes, pure and three-fourths combined and mulattoes and quadroons combined, the former class is shown to have obtained 62.0 per cent. of the score of the whites while the latter class obtained 83.5 per cent. of the white score.

The girls in Test I, classified by age, obtained the following percentages of the white score: Pure negroes, 68.0; three-fourths pure negroes, 71.3; mulattoes, 87.5; quadroons, 99.0. When the girls are arranged in two classes the results are as follows: The pure and three-fourths negroes combined scored 72.0 per cent. as high as the whites; the mulattoes and quadroons combined scored 89.3 per cent. as high as the whites.

The grade comparison for Test I shows that the pure negroes, boys and girls together, scored 73.3 per cent. as high as the whites; the three-fourths pure negroes scored 74.6 per cent. as high; the mulattoes scored 81.6 per cent. as high; the quadroons scored 87.9 per cent. as high as the whites. The two-division classification by grades shows that the pure and three-fourths negroes obtained 72.9 per cent. of the white score, and that the mulattoes and quadroons obtained 82.8 per cent. of the white score.

The percentages of negroes reaching or exceeding the average of the whites were as follows in Test I: Boys—Pure and three-fourths combined, 17.0; Mulattoes and quadroons combined, 38.5. Girls—Pure and three-fourths combined, 25.5;

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*There was not a sufficiently large number of quadroon boys to be included as a separate class in the tables of comparison. There were only five such boys in all, and only two of them were in any one age group, namely, age 14. These two scored higher than any of the other classes of negroes, but of course a result from such a small number is practically worthless. The quadroon boys are included in the groups of combined mulattoes and quadroons, however, and in the grade groups of quadroons, which contain both boys and girls.

Mulattoes and quadroons combined, 41.3. Grades—Pure and three-fourths combined, 25.4; Mulattoes and quadroons combined, 38.4.

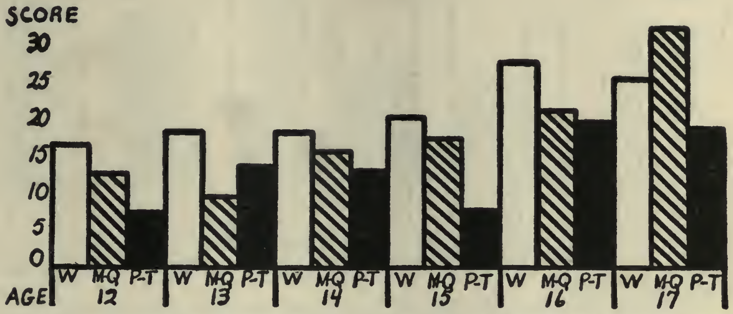

Fig. 16. Mixed Relations Test I—Scores of Whites, Mulattoes and Quadroons Combined, and Pure and Three-Fourths Negroes Combined—Boys—Richmond.*

*The white, the shaded and the black columns indicate the scores of the whites, the mulattoes and quadroons combined, and the pure and three-fourths negroes combined, respectively.

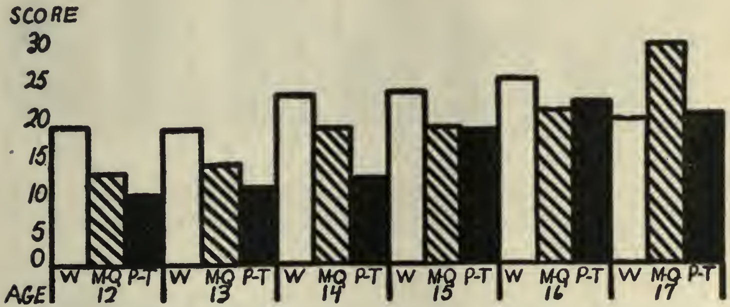

Fig. 17. Mixed Relations Test I—Scores of Whites, Mulattoes and Quadroons Combined, and Pure and Three-Fourths Negroes Combined—Girls—Richmond

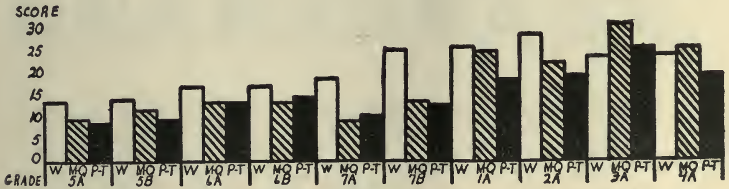

Fig. 18. Mixed Relations Test I—Scores of Whites, Mulattoes and Quadroons Combined, and Pure and Three-Fourths Negroes Combined—Grades—Richmond.

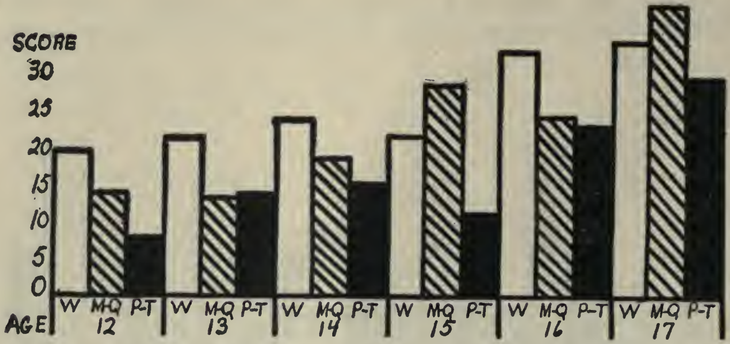

Fig. 19. Mixed Relations Test II—Scores of Whites, Mulattoes and Quadroons Combined, and Pure and Three-Fourths Negroes Combined—Boys—Richmond.

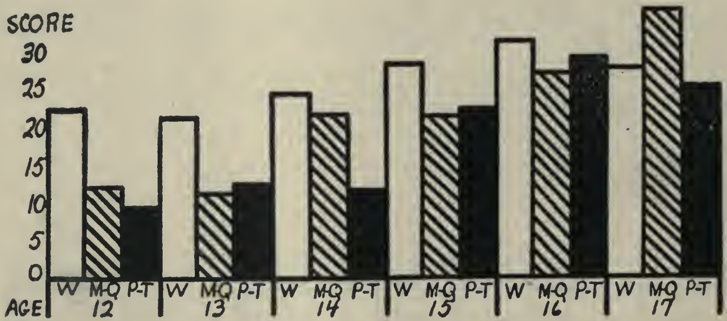

Fig. 20. Mixed Relations Test II—Scores of Whites, Mulattoes and Quadroons Combined, and Pure and Three-Fourths Negroes Combined—Girls—Richmond.

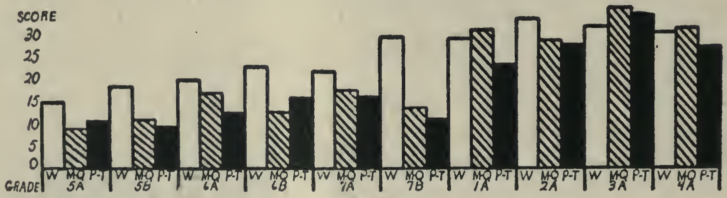

Fig. 21. Mixed Relations Test II—Scores of Whites, Mulattoes and Quadroons Combined, and Pure and Three-Fourths Negroes Combined—Grades—Richmond.

These figures show that in Test I the size of the score made by the negroes varies directly with the amount of their white blood. As judged by the averages, this is true without exception for both boys and girls and in both the age and the grade classifications. The size of the probable errors and the constancy of the results renders the differences reliable. In the two-division classification the differences are larger than in the four-division classification, as was to be expected, and the results here are especially reliable when the size of the probable errors is considered.

TABLE XXXIX.

MIXED RELATIONS TEST—DIFFERENCE BETWEEN SCORES OF THE WHITE AND EACH OF THE FOUR CLASSES OF COLORED SUBJECTS, BY AGE AND SEX—RICHMOND

(Minus signs indicate greater scores by the colored subjects.)

Ages	12	13	14	15	16	17	Av.	P.E.
Test I.								
Boys—Pure	10.0	6.0	8.3	9.6	8.5	6.9	8.2	.4
Boys—Three-Fourths	7.5	1.3	—.5	13.6	6.8	6.3	5.8.	1.3
Boys—Mulattoes	4.0	10.9	5.5	2.9	6.8	—6.9	3.9	1.4
Girls—Pure	9.2	7.5	10.1	7.9	8.0	—1.6	6.8	1.0
Girls—Three-Fourths	9.0	7.4	11.3	2.2	1.6	3.8	5.9	1.2
Girls—Mulattoes	6.3	3.4	7.0	4.9	4.9	—9.7	2.8	1.5
Girls—Quadroons	..	7.3	—.3	3.0	1.6	—10.9	.1	1.8
Test II.								
Boys—Pure	11.8	8.3	11.3	4.0	9.0	8.1	8.7	.7
Boys--Three-Fourths	10.5	4.0	5.3	17.5	11.0	1.3	8.3	1.6
Boys—Mulattoes	5.5	11.5	9.1	—5.5	8.5	—4.9	4.0	2.2
Girls—Pure	13.4	13.3	11.0	8.8	3.2	1.0	8.4	1.5
Girls-Three-Fourths	12.6	6.3	13.5	2.3	2.0	5.8	7.1	1.4
Girls—Mulattoes	10.3	9.9	4.2	8.0	5.3	—7.5	5.0	1.6
Girls—Quadroons	..	12.9	.1	1.6	.9	—9.7	1.2	1.8
Test I.								
Boys								
Pure and Three-Fourths	9.2	4.7	5.1	12.3	8.1	6.6	7.7	.8
Mulattoes and Quadroons	4.0	8.8	2.4	2.9	6.8	—6.9	3.0	1.2
Girls								
Pure and Three-Fourths	9.1	7.4	10.8	5.0	3.0	—.4	5.8	1.2
Mulattoes and Quadroons	6.3	4.3	4.6	4.6	4.2	—10.0	2.3	1.4
Test II.								
Boys								
Pure and Three-Fourths	11.5	7.2	8.8	10.8	9.7	4.8	8.8	.7
Mulattoes and Quadroons	5.5	8.1	5.6	—6.4	8.5	—4.9	2.7	2.0
Girls								
Pure and Three-Fourths	12.8	8.8	12.5	6.0	2.3	2.1	7.4	1.4
Mulattoes and Quadroons	10.3	10.4	2.8	7.0	4.4	—8.1	4.5	1.7

TABLE XL.

MIXED RELATIONS TEST—DIFFERENCE BETWEEN SCORES OF THE WHITE AND EACH OF THE FOUR CLASSES OF COLORED SUBJECTS, BY GRADES—RICHMOND

(Minus signs indicate greater scores by the colored subjects.)

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Test I.												
Pure	5.5	3.4	4.4	4.6	5.1	13.2	7.1	10.6	—5.5	5.8	5.4	.8
Three-Fourths	3.8	5.3	3.2	— .2	9.7	11.5	7.8	8.0	1.1	1.0	5.1	.9
Mulattoes	3.3	1.6	3.7	4.0	9.4	13.3	2.3	6.0	—6.9	— .7	3.6	1.0
Quadroons	8.6	4.9	4.5	3.8	..	..	—1.8	5.8	—9.0	—6.3	1.3	1.6
Test II.												
Pure	6.1	8.2	7.3	7.4	3.6	17.9	6.5	5.2	—3.2	1.8	6.1	.9
Three-Fourths	2.2	9.1	7.7	6.6	7.4	18.8	4.4	6.4	—2.4	5.9	6.6	.9
Mulattoes	5.7	5.9	4.1	8.6	4.4	16.0	.4	5.3	—3.8	— .3	4.6	1.0
Quadroons	10.8	9.0	—2.7	14.6	..	..	—6.1	3.9	—4.3	—4.4	2.6	2.1
Test I.												
Pure and Three-Fourths	4.7	4.5	3.8	2.6	8.3	12.3	7.4	9.0	—2.2	4.3	5.5	.8
Mulattoes and Quadroons	3.8	2.1	3.8	3.9	9.4	11.8	1.0	6.0	—7.6	—1.8	3.2	1.0
Test II.												
Pure and Three-Fourths	4.3	8.7	7.5	7.0	5.8	18.4	5.6	6.0	—2.7	3.0	6.4	.8
Mulattoes and Quadroons	5.9	6.3	3.1	10.1	4.4	15.7	—1.8	5.0	—4.0	—1.1	4.4	1.1

TABLE XLI.

MIXED RELATIONS TEST—PERCENTAGE OF THE SCORE OF THE WHITE OBTAINED BY EACH OF THE FOUR CLASSES OF COLORED SUBJECTS, BY AGE AND SEX—RICHMOND

Ages	12	13	14	15	16	17	Av.	P.E.
Test I.								
Boys—Pure	37	67	54	52	70	73	58.8	3.8
Boys—Three-Fourths	53	93	103	32	76	76	72.2	7.0
Boys—Mulattoes	75	39	69	85	76	127	78.5	6.3
Girls—Pure	52	58	56	66	68	108	68.0	4.5
Girls—Three-Fourths	53	59	51	90	94	81	71.3	5.9
Girls—Mulattoes	67	81	70	79	80	148	87.5	7.0
Girls—Quadroons	..	59	101	87	94	154	99.0	8.7
Test II.								
Boys—Pure	38	60	53	82	73	77	63.8	4.5
Boys—Three-Fourths	45	81	78	20	67	96	64.5	7.3
Boys—Mulattoes	71	45	62	125	74	114	81.8	8.7
Girls—Pure	39	37	56	70	90	96	64.7	7.3
Girls—Three-Fourths	43	70	46	92	94	79	70.7	6.3
Girls—Mulattoes	53	53	83	72	83	127	78.5	6.6
Girls—Quadroons	..	39	100	94	97	135	93.0	8.4
Test I.								
Boys—Pure and Three-Fourths	42	74	72	38	71	75	62.0	5.2
Mulattoes and Quadroons	75	51	87	85	76	127	83.5	5.6
Girls—Pure and Three-Fourths	52	59	53	78	88	102	72.0	5.9
Mulattoes and Quadroons	67	76	80	80	83	150	89.3	7.0

Ages	12	13	14	15	16	17	Av.	P.E.
Test II.								
Boys—Pure and Three-Fourths	39	66	63	51	71	86	62.7	4.2
Mulattoes and Quadroons	71	61	77	129	74	114	87.7	8.0
Girls—Pure and Three-Fourths	42	58	50	79	93	92	69.0	6.6
Mulattoes and Quadroons	53	50	89	76	86	129	80.5	7.3

TABLE XLII.

MIXED RELATIONS TEST—PERCENTAGE OF THE SCORE OF THE WHITE OBTAINED BY EACH OF THE FOUR CLASSES OF COLORED SUBJECTS, BY GRADES—RICHMOND

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Test I.												
Pure	58	76	74	73	72	47	72	62	124	75	73.3	2.8
Three-Fourths	71	62	81	101	46	54	69	71	95	96	74.6	3.9
Mulattoes	75	89	78	76	48	47	91	79	130	103	81.6	4.4
Quadroons	34	65	74	78	..	..	107	79	139	127	87.9	8.1
Test II.												
Pure	59	54	63	68	84	38	78	85	110	94	73.3	4.4
Three-Fourths	85	49	61	71	66	35	85	81	107	80	72.0	4.2
Mulattoes	62	67	79	63	80	45	99	84	112	101	79.2	4.2
Quadroons	28	50	113	37	..	..	121	89	113	115	83.2	10.2
Test I.												
Pure and Three-Fourths	64	68	78	85	54	51	70	68	110	81	72.9	3.1
Mulattoes and Quadroons	71	85	78	77	48	53	96	79	133	108	82.8	4.7
Test II.												
Pure and Three-Fourths	71	52	62	70	74	37	81	82	108	90	72.7	3.6
Mulattoes and Quadroons	61	65	84	56	80	46	106	85	112	104	79.9	4.7

TABLE XLIII.

MIXED RELATIONS TEST—PERCENTAGE OF EACH OF TWO CLASSES OF COLORED SUBJECTS REACHING OR EXCEEDING THE AVERAGE OF THE WHITE, BY AGE AND SEX AND BY GRADES—RICHMOND

Ages	12	13	14	15	16	17	..	..	..	..	Av.	P.E.
Test I.												
Boys—Pure and Three-Fourths	0	27	36	0	25	14	..	..	..	..	17.0	4.2
Mulattoes and Quadroons	25	12	40	29	25	100	..	..	..	..	38.5	7.3
Girls—Pure and Three-Fourths	8	23	8	25	33	56	..	..	..	..	25.5	4.2
Mulattoes and Quadroons	17	28	39	38	33	93	..	..	..	..	41.3	5.9
Test II.												
Boys—Pure and Three-Fourths	0	18	25	12	17	43	..	..	..	..	19.2	3.4
Mulattoes and Quadroons	25	12	33	86	25	100	..	..	..	..	46.8	10.1
Girls—Pure and Three-Fourths	8	7	12	36	56	44	..	..	..	..	27.2	6.3
Mulattoes and Quadroons	12	21	56	38	37	93	..	..	..	..	42.8	7.3

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	..	..
Test I.												
Pure and Three-Fourths	15	14	38	29	20	0	17	14	67	40	25.4	3.6
Mulattoes and Quadroons	27	31	36	18	0	20	50	41	94	67	38.4	5.2
Test II.												
Pure and Three-Fourths	26	19	19	20	25	0	48	21	86	40	30.4	4.2
Mulattoes and Quadroons	10	20	31	17	43	0	76	29	89	60	37.5	6.0

We may conveniently average the percentages obtained by the boys, girls and grades in each class. When this is done the scores for the four classes of negroes, in terms of percentages of the score of whites, are as follows: Pure negroes, 66.7; negroes three-fourths pure, 72.7; mulattoes, 82.5; quadroons, 93.4. The scores of the two-division classification, in the same terms, are: Pure and three-fourths negroes, 69.0; mulattoes and quadroons, 85.2. Averaging the percentages of boys, girls and grades that reached or exceeded the average score of whites, we find that 22.6 per cent. of the combined pure and three-fourths negroes, and 39.4 per cent. of the combined mulattoes and quadroons reached the white average.

In Test II the same situation occurs. The percentages of the score of the whites obtained by the pure, the three-fourths pure and the mulatto boys were 63.8, 64.5 and 81.8, respectively. For the girls, the percentages obtained by the pure negroes, the negroes three-fourths pure, the mulattoes and the quadroons were, respectively, 64.7, 70.7, 78.5 and 93.0. For the grades, the percentages, in the same order, were 73.3, 72.0, 79.2 and 83.2.*

The combined pure and three-fourths pure negroes and the combined mulattoes and quadroons scored, in Test II, the following respective percentages of the score of the whites: Boys—62.7 and 87.7; Girls—69.0 and 80.5; Grades—72.7 and 79.9.

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*It should be noted that in the comparison by grades in Test II the pure negroes scored 1.3 per cent. higher than those three-fourths pure. In the grade comparison of the completion test the pure negroes also scored higher, by 2.0 per cent., than the three-fourths negroes. These are the only instances in which subjects with a greater amount of white blood were inferior to those with a lesser amount. As was previously pointed out, comparisons by grades are not as likely to reveal marked or reliable differences as are comparisons by ages; and as was also pointed out, the classes of pure and three-fourths pure negroes may not have been as well separated as the other classes.

The percentages of negroes reaching or exceeding the average of the whites in Test II were as follows: Boys—Pure and three-fourths, 19.2; Mulattoes and quadroons, 46.8. Girls—Pure and three-fourths, 27.2; Mulattoes and quadroons, 42.8. Grades—Pure and three-fourths, 30.4; Mulattoes and quadroons, 37.5.

If we average for Test II the percentages obtained by the boys, girls and grades in each class, we find that the pure negroes obtained 67.3 per cnt. of the score of the whites; that the three-fourths pure negroes obtained 69.1 per cent. of the score of the whites; that the mulattoes obtained 79.8 per cent. of the white score; and that the quadroons obtained 88.1 per cent. of the white score. The pure and three-fourths negroes, boys, girls and grades, scored 68.1 per cent. as high as the whites; the mulattoes and quadroons, boys, girls and grades, scored 82.7 per cent. as high as the whites. Averaging the percentages of boys, girls and grades that reached or exceeded the average white score, we find that 25.6 per cent. of the pure and three-fourths pure negroes reached the white average; and that the white average was reached by 42.4 per cent. of the mulattoes and quadroons.

The results of the completion test appear in Tables 44 and 45 and in Figures 22-24. The comparisons are made in Tables 46-50. These latter tables show the following results:

In the case of boys, the pure negroes obtained 65.3 per cent. of the score of the whites; the three-fourths pure negroes obtained 76.2 per cent.; and the mulattoes obtained 79.2 per cent. For girls, the percentages for the four classes of negroes, pure, three-fourths pure, mulattoes and quadroons, were, respectively, 74.3, 77.7, 81.8 and 95.8. For grades, the percentages were: Pure negroes, 81.4; three-fourths pure, 79.4; mulattoes, 82.9; quadroons, 92.2. When the pure and three-fourths pure negroes and the mulattoes and quadroons are grouped together, it appears that the pure and three-fourths pure boys scored 68.7 per cent. as high as the whites, and that the mulatto and quadroon boys scored 82.0 per cent. as high as the whites. The girls, pure and three-fourths pure, obtained 77.3 per cent. of the white score; and the girls, mulattoes and quadroons, obtained 83.5 per cent. of the white score. In the case of the grades, the pure and three-fourths pure negroes scored 80.2 per cent. as high as the whites, and the mulattoes and quadroons scored 83.4 per cent. as high.

TABLE XLIV.

Completion Test—Scores of Colored Subjects—Richmond—Classified by Racial Purity, Age and Sex

Ages		10	11	12	13	14	15	16	17	18	19
Boys											
Pure	Av.	..	..	12.5	12.7	15.5	12.0	19.2	20.0	34.0	31.5
	A.D.	..	..	1.0	3.2	5.7	3.0	2.2	5.0	0.	3.5
Three-Fourths	Av.	..	8.6	15.0	17.3	14.7	10.2	16.0	36.3	..	..
	A.D.	..	2.6	5.0	3.0	6.7	3.7	6.0	3.6	..	..
Mulattoes	Av.	..	..	13.2	11.4	15.5	20.7	23.6	32.0	29.0	..
	A.D.	..	..	2.5	5.5	6.5	13.2	11.3	1.0	8.6	..
Quadroons	Av.	..	..	..	..	19.5	..	..	..	..	..
	A.D.	..	..	..	..	5.5	..	..	..	..	..
Girls											
Pure	Av.	..	..	12.7	13.8	16.4	19.2	23.0	27.0	..	..
	A.D.	..	..	3.2	4.4	3.5	4.5	2.0	9.4	..	..
Three-Fourths	Av.	..	..	13.5	15.4	15.0	22.6	27.1	22.5	23.5	..
	A.D.	..	..	1.3	2.8	4.7	3.3	4.1	2.5	4.5	..
Mulattoes	Av.	12.0	13.7	15.1	14.3	21.0	21.1	22.7	29.1	22.5	..
	A.D.	5.0	3.2	4.8	4.5	8.5	5.4	5.6	6.1	2.1	..
Quadroons	Av.	..	18.6	..	13.7	21.0	35.5	24.6	30.5	27.7	..
	A.D.	..	1.3	..	2.2	7.0	2.5	4.6	1.0	3.2	..
Boys—Pure and Three-Fourths	Av.	..	8.7	13.3	14.0	15.2	11.1	18.1	27.0	33.6	30.6
	A.D.	..	2.2	2.3	3.4	6.0	3.3	3.5	8.8	.6	2.6
Mulattoes and Quadroons	Av.	..	9.0	13.2	13.1	16.8	21.2	23.6	32.0	29.0	..
	A.D.	..	1.0	2.5	6.6	6.1	12.2	11.3	1.0	8.6	..
Girls—Pure and Three-Fourths	Av.	..	20.5	13.2	14.8	15.5	20.7	26.2	26.0	22.6	..
	A.D.	..	3.5	1.8	3.4	4.2	4.1	3.7	8.4	4.2	..
Mulattoes and Quadroons	Av.	12.0	15.8	15.1	14.2	21.0	23.3	23.1	29.5	24.6	29.0
	A.D.	5.0	3.1	4.8	3.9	8.0	6.5	5.5	4.7	3.6	0.

TABLE XLV.

Completion Test—Scores of Colored Subjects—Richmond—Classified by Racial Purity and Grades

Grades		5A	5B	6A	6B	7A	7B	1A	2A	2B	3A	4A
Pure	Av.	10.6	14.0	14.2	19.5	17.8	17.2	17.8	23.8	29.0	29.3	26.8
	A.D.	2.4	1.4	3.7	2.0	5.2	3.7	4.3	4.4	4.0	7.6	9.7
Three-Fourths	Av.	11.9	13.4	13.3	13.5	14.8	16.0	21.5	27.5	25.8	28.7	27.6
	A.D.	5.5	3.0	3.7	2.5	4.2	5.2	5.6	5.8	5.2	3.7	2.0
Mulattoes	Av.	10.5	12.0	14.9	18.2	16.2	17.2	23.2	28.0	21.0	27.2	31.5
	A.D.	3.6	2.7	4.9	4.0	3.7	4.0	8.7	6.8	4.3	5.7	5.6
Quadroons	Av.	16.0	16.5	15.3	11.6	..	..	26.2	28.5	24.6	30.0	29.3
	A.D.	1.0	2.5	3.6	1.3	..	..	2.2	7.0	2.6	2.0	.3
Pure and Three-Fourths	Av.	11.2	13.6	13.8	16.5	16.0	16.5	19.4	26.2	26.7	29.0	27.1
	A.D.	4.1	2.4	3.6	3.2	4.7	4.3	4.7	5.5	5.0	5.1	7.1
Mulattoes and Quadroons	Av.	11.0	12.6	15.0	16.5	16.2	16.5	24.2	28.1	21.7	28.1	31.0
	A.D.	3.7	3.0	4.4	4.5	3.7	4.3	6.7	6.8	4.2	4.5	4.8

The percentages of negroes reaching or exceeding the average score of the whites were as follows: Boys—Pure and three-fourths pure, 19.0; Mulattoes and quadroons, 44.8. Girls—Pure and three-fourths pure, 23.2; Mulattoes and quadroons, 31.5. Grades—Pure and three-fourths pure, 25.9; Mulattoes and quadroons, 27.9.

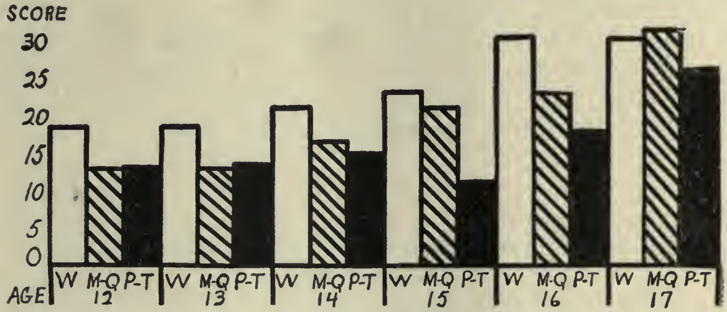

Fig. 22. Completion Test—Scores of Whites, Mulattoes and Quadroons Combined, and Pure and Three-Fourths Negroes Combined—Boys —Richmond.

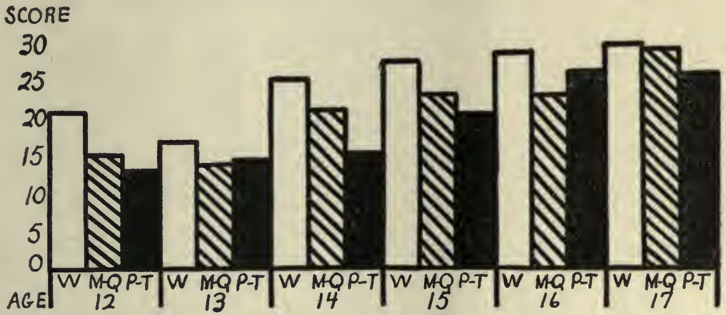

Fig. 23. Completion Test—Scores of Whites, Mulattoes and Quadroons Combined, and Pure and Three-Fourths Negroes Combined—Girls—Richmond.

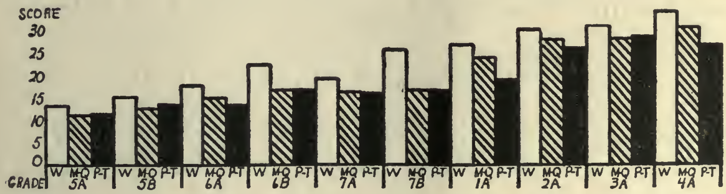

Fig. 24. Completion Test—Scores of Whites, Mulattoes and Quadroons Combined, and Pure and Three-Fourths Negroes Combined—Grades—Richmond.

If we average the percentages for boys, girls and grades, we find that the pure negroes scored 73.7 per cent. as high as the whites, the three-fourths pure negroes scored 77.8 per cent. as high, the mulattoes scored 81.3 per cent. as high, and the quadroons scored 94.0 per cent. as high as the whites. The pure and three-fourths pure negroes, combined, obtained 75.4 per cent. of the white score; the mulattoes and quadroons, combined, obtained 83.0 per cent. of the white score. In terms of the percentage of negroes reaching or exceeding the average of the whites, the results for boys, girls and grades are: Pure and three-fourths pure negroes, 22.7 per cent.; Mulattoes and quadroons, 34.7 per cent.

TABLE XLVI.

COMPLETION TEST—DIFFERENCE BETWEEN SCORES OF THE WHITE AND EACH OF THE FOUR CLASSES OF COLORED SUBJECTS, BY AGE AND SEX—RICHMOND

(Minus signs indicate greater scores by the colored subjects.)

Ages	12	13	14	15	16	17	Av.	P.E.
Boys								
Pure	6.2	6.0	5.7	11.4	11.5	10.7	8.6	.9
Three-Fourths	3.7	1.4	6.5	13.2	14.7	—5.6	5.6	2.0
Mulattoes	5.5	7.3	5.7	2.7	7.1	—1.3	4.5	.9
Girls								
Pure	8.2	3.2	8.9	8.5	5.9	3.0	6.3	.8
Three-Fourths	7.4	1.6	10.3	5.1	1.8	7.5	5.6	1.0
Mulattoes	5.8	2.7	4.3	6.6	6.2	.9	4.4	.6
Quadroons	..	3.3	4.3	—7.8	4.3	—.5	.7	1.5
Boys								
Pure and Three-Fourths	5.4	4.7	6.0	12.3	12.6	3.7	7.4	1.2
Mulattoes and Quadroons	5.5	5.6	4.4	2.2	7.1	—1.3	3.9	.8
Girls								
Pure and Three-Fourths	7.7	2.2	9.8	7.0	2.7	4.0	5.6	.9
Mulattoes and Quadroons	5.8	2.8	4.3	4.4	5.8	.5	3.9	.5

TABLE XLVII.

COMPLETION TEST—DIFFERENCE BETWEEN SCORES OF THE WHITE AND EACH OF THE FOUR CLASSES OF COLORED SUBJECTS, BY GRADES—RICHMOND

(Minus signs indicate greater scores by the colored subjects.)

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Pure	2.7	1.1	3.4	3.0	1.6	8.4	9.2	6.7	1.9	7.7	4.6	.7
Three-Fourths	1.4	1.7	4.8	9.0	4.6	9.6	5.5	3.0	2.5	6.9	4.8	.6
Mulattoes	2.8	3.1	2.7	4.3	3.2	8.4	3.8	2.5	4.0	3.0	3.8	.3
Quadroons	—2.7	—1.4	2.3	10.9	..	..	.8	2.0	1.2	5.2	2.3	.9
Pure and Three-Fourths	2.1	1.5	3.8	6.0	3.4	9.1	7.6	4.3	2.2	7.4	4.7	.6
Mulattoes and Quadroons	2.3	2.5	2.6	6.0	3.2	9.1	2.8	2.4	3.1	3.5	3.7	.4

TABLE XLVIII.

Completion Test—Percentage of the Score of the White Obtained by Each of the Four Classes of Colored Subjects, by Age and Sex—Richmond

Ages	12	13	14	15	16	17	Av.	P.E.
Boys								
Pure	73	68	73	50	63	65	65.3	2.1
Three-Fourths	81	93	69	43	53	118	76.2	7.3
Mulattoes	71	62	73	88	77	104	79.2	3.8
Girls								
Pure	61	81	64	70	80	90	74.3	3.2
Three-Fourths	65	91	59	82	94	75	77.7	3.8
Mulattoes	72	84	83	76	79	97	81.8	2.1
Quadroons	..	81	83	128	85	102	95.8	5.7
Boys								
Pure and Three-Fourths	72	75	71	47	59	88	68.7	3.5
Mulattoes and Quadroons	71	71	79	90	77	104	82.0	3.5
Girls								
Pure and Three-Fourths	63	87	61	75	91	87	77.3	3.8
Mulattoes and Quadroons	72	84	83	84	80	98	83.5	1.8

TABLE XLIX.

Completion Test—Percentage of the Score of the White Obtained by Each of the Four Classes of Colored Subjects, by Grades—Richmond

Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	Av.	P.E.
Pure	79	93	81	86	92	68	66	78	94	77	81.4	2.0
Three-Fourths	89	89	76	59	76	63	80	90	92	80	79.4	2.3
Mulattoes	78	79	85	80	83	68	86	92	87	91	82.9	1.3
Quadroons	121	109	87	50	..	..	97	93	96	85	92.2	4.2
Pure and Three-Fourths	84	90	79	73	82	65	72	86	93	78	80.2	1.7
Mulattoes and Quadroons	82	83	86	73	83	65	90	92	90	90	83.4	1.6

TABLE L.

Completion Test—Percentage of Each of Two Classes of Colored Subjects Reaching or Exceeding the Average of the White, by Age and Sex and by Grades—Richmond

Ages	12	13	14	15	16	17	..	..	..	..	Av.	P.E.
Boys—Pure and Three-Fourths	17	18	36	0	0	43	..	..	..	..	19.0	4.9
Mulattoes and Quadroons	12	37	33	50	37	100	..	..	..	..	44.8	7.0
Girls—Pure and Three-Fourths	0	57	9	7	22	44	..	..	..	..	23.2	6.3
Mulattoes and Quadroons	25	30	28	31	25	50	..	..	..	..	31.5	2.0
Grades	5A	5B	6A	6B	7A	7B	1A	2A	3A	4A	..	..
Pure and Three-Fourths	25	39	14	12	33	0	10	29	57	40	25.9	3.6
Mulattoes and Quadroons	41	27	29	17	29	0	43	29	44	20	27.9	2.4

It is evident that the results from the completion test show the same general standing for the four classes of negroes that was brought out by the mixed relations test: the subjects with the greater amount of white blood were superior. And the size of the probable errors, particularly in the case of the two-division classification, renders the results reliable.

The standing of the various classes of negroes in the mixed relations tests, I and II, and in the completion test may be averaged. When this is done the figures show that the pure negroes scored 69.2 per cent. as high as whites; that the three-fourths pure negroes scored 73.2 per cent. as high as whites; that the mulattoes scored 81.2 per cent. as high as whites; and that the quadroons obtained 91.8 per cent. of the white score. The pure and three-fourths pure negroes, combined, obtained 70.8 per cent. of the score of the white subjects; the mulattoes and quadroons, combined, obtained 83.6 per cent. of the score of the whites.

This suggests that it is sometimes questioned as to how far external appearances are indicative of racial purity. It is held that a certain proportion of the offspring of mixed races will not show the blood characteristics which their heredity would seem to warrant. This may be true, and the Mendelian laws of inheritance may furnish a basis for such variation. But in the main, children conform closely to the characteristics of their parents in all respects, and such variations as occur will offset each other in any considerable number of persons, and leave the group type predominant. Certainly the results here obtained indicate that the correlation between skin color and racial purity is high.

There was apparently nothing except native racial ability that could bring about the results found herein for the different classes of negroes. It is possible, indeed, that the lighter negroes were of a better social class than the darker. But if this was true, it must be that the mixed bloods attained to a better social standing because of their greater capacity. For among negroes in general there are no considerable social distinctions based on color. A colored person is a colored person, whether he be mulatto or negro, and all mingle together as one race. Pyle, in a quotation previously given, reports that of the negroes tested by him, those of better social class made higher scores. And it would not be surprising if it were found that mulattoes constituted the bulk of the superior social class, and only a minority of the inferior class. It would be surprising, in view of the results found here, if it were otherwise. But any such distribution should be ascribed to the greater inherent capacity of negroes of lighter skin.

No social or material gulf, such as that which separates the white and colored races in this country, is to be found among the negroes themselves. Such distinctions as there are, and however based, are very minor as compared with the great inter-racial distinction. And to a marked degree the general environment of colored children is the same for all. With no great variations, they all attend the same schools, live in the same neighborhoods, grow up in the same home surroundings, share the same cultural advantages, meet the same opportunities, undergo the same experiences. They live almost in a world of their own, which is but one stratum or level of our mixed society. This is particularly true of the selected group of negroes found in the upper grades of the schools. And yet the differences, as revealed by the mental tests, between the pure negroes and the mulattoes, on the one hand, and the mulattoes and the whites, on the other, are not unlike in amount. The mulattoes who, with the pure negroes, live in the comparatively uniform colored environment, which is so greatly different from the white environment, are yet almost as near to the whites as to the pure negroes when put to psychological tests. This fact becomes especially noteworthy when it is considered that the greater number of mulattoes are probably descended from an inferior element among the whites, and probably from an inferior element among the negroes also.

Such considerations indicate that it is a native ability and not an acquired capacity that differentiates the mixed and the pure negroes, and that skin color is its outward sign. They also indicate that the tests used are primarily tests of native capacity, and that consequently the differences found between whites and negroes as a whole are innate differences.

Comparative Variabilities

In recent years a number of writers have called attention to the importance of differences in the variability of groups from their central tendencies. It is pointed out that two groups, as two races or two sexes, may be of the same average capacity, but that if one of these groups is more variable than the other, certain significant differences will appear.

The more variable group will produce a greater number of individuals of very high capacity and also a greater number of very low capacity; within the less variable group there will be more conformity to the group type and less divergence toward the extremes. In the former case there will be a greater number of geniuses and of moral heroes than in the latter, and also a greater number of idiots and of moral degenerates. This will result in marked differences in the relative attainments of the groups as wholes. Progress depends upon the few who stand out from the crowd and invent new and better ways of doing things. The few conceive and the many appropriate their conceptions, in all realms of human activity. In mechanical and material progress, in science, in art, in literature, in religion, in politics, it is the geniuses who make progress possible. And it follows that a variable group, other things being equal, will achieve a higher type of civilization than one which is less variable.

In discussing this matter, Woodworth writes as follows: "The distribution of a trait is for some purposes more important than the average. Let us suppose, for instance, that two groups were the same in their average mental ability, but that one group showed little variation, all of its members being much alike and of nearly the average intelligence, while the other group showed great variability, ranging between the extremes of idiocy and genius. It is evident that the two groups, though equal on the average, would be very unequal in dealing with a situation which demanded great mental ability. One master mind could supply ideas for the guidance of the group, and his value would far outweigh the load of simpletons which the group must carry." ('10, p. 2).

Thorndike ('10) writes to the same effect. He claims that men are more variable than women, and that on this account the greater part of the genius and the stupidity of the world is found among men. In discussing racial capacity, he says: "The comparison in variability is, as in the case of the sexes, of great practical importance. The ability of a hundred of its most gifted representatives often counts more for a nation's or a race's welfare than the ability of a million of its mediocrities." '10, pp. 53-54).

While the importance of variability is thus recognized, there is as yet very little evidence bearing upon the relative variability of diffrent races. In summing up the psychological results available in 1910, Woodworth wrote as follows: "The dead level of intelligence, which is sometimes supposed to obtain among backward races, is not borne out by psychological tests, since individual differences are abundantly found among all races, and, indeed, the variability of different groups seems, from these tests, to be about on a par." ('10, p. 15). Hrdlicka ('98) and Le Bon ('98), as quoted in Chapter I, claim that in physical traits whites are more variable than negroes. Strong ('13) states, as previously quoted, that the lighter-colored negroes among the 122 tested by her were more variable than those of darker color. Mayo, after discussing the variability of whites and negroes, writes as follows concerning the groups studied by him: "In our own study of the two groups of high school pupils, however, the fact of greater racial mental variability is not at all pronounced, though the whites were slighly more variable. The average deviation of the white group from their mean scholastic attainment was 7, while that of the colored group was 6.5." ('13, p. 69). In addition to the somewhat inconclusive findings of these writers, there do not seem to be any reliable measurements bearing upon the problem.

At present we have no good method of measuring the variability of groups. Of course the actual variabilities may be compared in such terms as the average deviation or the probable error. But this will be misleading if the groups differ considerably in their standing in the capacity in question. A higher average standing generally implies a greater average deviation. If an average score of 30 has an average deviation of 10, an average score of 20 in the same trait will have a smaller deviation. The actual size of the deviations must therefore be considered in connection with the size of the average scores.

In order to overcome this difficulty, Pearson has proposed that the deviations should be divided by the group averages before a comparison is made. But this procedure is open to the objection that it is not certain that deviations vary in proportion to the size of the central tendencies from which they are derived. There is reason to believe that they more nearly vary in proportion to the size of the square roots of the central tendencies. Accordingly Thorndike ('04) has suggested that actual variabilities should be divided by the square roots of averages rather than by the averages themselves.

Since there is thus no single reliable measure of variability, our procedure in the following comparisons will be to set forth the average deviations, the Pearson coefficients, i.e., the deviations divided by the averages, and the Thorndike coefficients, i.e., the deviations divided by the square roots of the averages. And since none of these methods is wholly free from objection, the average of all three is presented in each case as a combined coefficient.

The variabilities are given in this manner for the various classes of colored subjects in terms of percentages of the variability of white subjects of the same ages or grades. The variability of the whites is therefore to be considered as 100 in all cases. The figures for the separate ages and grades are omitted for the sake of brevity, and only the averages of the different ages and grades are presented. The actual deviations from which the figures are derived are shown in the tables in this and the foregoing chapters which set forth the scores. Only the Richmond pupils are treated in the comparisons.

Table 51 shows the relative variabilities of the different classes of subjects in the age at which they reached the school grades studied. From the averages it appears that the pure negroes, the three-fourths negroes, the mulattoes and the quadroons were 66, 91, 87 and 74 per cent., respectively, as variable as the whites; that the pure and three-fourths negroes combined and the mulattoes and quadroons combined were, respectively, 83 and 95 per cent. as variable as the whites; and that the colored pupils of all classes combined

TABLE LI.

AGES—VARIABILITY OF THE COLORED SUBJECTS IN PERCENTAGES OF THE VARIABILITY OF THE WHITE—RICHMOND—BY GRADES

	Average Deviation	Pearson Coefficient	Thorndike Coefficient	Av.
Pure Negroes	68	65	66	**66**
Three-Fourths	92	90	91	**91**
Mulattoes	88	86	87	**87**
Quadroons	74	74	74	**74**
Pure and Three-Fourths	85	81	82	**83**
Mulattoes and Quadroons	96	94	95	**95**
All colored	90	87	89	**89**

had 89 per cent. of the white variability. The average deviations, the Pearson and the Thorndike coefficients all give practically the same result: the negroes were less variable than the whites.

The uniform behavior of the figures for age variability is in contrast with the more uncertain nature of those which show the variability of the scores in the tests. Tables 52-55 make the test comparisons. Relying upon the averages, it appears that the pure negro boys are 72, 106 and 63 per cent. as variable as the white boys in the Mixed Relations Test I, the Mixed Relations Test II and the completion test, respectively; that the pure negro girls are 104, 98 and 84 per cent. as variable as the white girls in these respective tests; and that the pure negroes when compared by grades are 85, 85 and 89 per cent. as variable as the whites in these tests. The figures which show the relative variability of the three-fourths pure negroes in the three tests, in the order mentioned, are as follows: Boys—69, 86 and 82 per cent.; Girls—101, 88 and 56 per cent.; Grades—99, 110 and 85 per cent. The relative variability of the mulattoes in the three tests is: Boys—90, 87 and 115 per cent.; Girls—123, 104 and 102 per cent.; Grades—109, 102 and 100 per cent. The percentages for the quadroons are: Girls—118, 84 and 57; Grades—69, 44 and 47. These figures are not subject to any sure interpretation. But it appears to be very probable that the pure and the three-fourths pure negroes are less variable than whites, and that the quadroons are also less variable. The comparatively small number of quadroons, however, may be a factor here. The mulattoes appear to have a variability as great as that of the whites.

TABLE LII.

Mixed Relations Test—Variability of the Colored Subjects in Percentages of the Variability of the White—Richmond

Test I.

Boys	Average Deviation	Pearson Coefficient	Thorndike Coefficient	Av.
Pure Negroes	54	92	71	72
Three-Fourths	58	81	68	69
Mulattoes	79	101	90	90
Pure and Three-Fourths	65	106	82	84
Mulattoes and Quadroons	89	107	97	98
All colored	90	124	106	107
Girls				
Pure Negroes	85	125	103	104

	Average Deviation	Pearson Coefficient	Thorndike Coefficient	Av.
Three-Fourths	85	118	100	**101**
Mulattoes	114	131	123	**123**
Quadroons	117	118	118	**118**
Pure and Three-Fourths	88	121	103	**104**
Mulattoes and Quadroons	114	128	121	**121**
All colored	103	123	112	**113**
Grades				
Pure Negroes	72	98	84	**85**
Three-Fourths	86	114	98	**99**
Mulattoes	98	120	109	**109**
Quadroons	64	73	69	**69**
Pure and Three-Fourths	81	111	95	**96**
Mulattoes and Quadroons	94	112	103	**103**
All Colored	89	114	102	**102**
Test II.				
Boys				
Pure Negroes	84	130	104	**106**
Three-Fourths	68	106	85	**86**
Mulattoes	78	96	86	**87**
Pure and Three-Fourths	85	135	108	**109**
Mulattoes and Quadroons	92	105	99	**99**
All Colored	101	128	114	**114**
Girls				
Pure Negroes	78	120	96	**98**
Three-Fourths	73	104	88	**88**
Mulattoes	92	117	104	**104**
Quadroons	81	87	84	**84**
Pure and Three-Fourths	83	120	100	**101**
Mulattoes and Quadroons	86	107	96	**96**
All Colored	89	114	101	**101**
Grades				
Pure Negroes	72	99	85	**85**
Three-Fourths	93	129	109	**110**
Mulattoes	91	115	101	**102**
Quadroons	40	48	44	**44**
Pure and Three-Fourths	85	117	100	**101**
Mulattoes and Quadroons	84	105	95	**95**
All Colored	87	115	100	**101**

TABLE LIII.

COMPLETION TEST—VARIABILITY OF THE COLORED SUBJECTS IN PERCENTAGES OF THE VARIABILITY OF THE WHITE—RICHMOND

Boys	Average Deviation	Pearson Coefficient	Thorndike Coefficient	Av.
Pure Negroes	50	77	62	**63**
Three-Fourths	71	94	82	**82**
Mulattoes	102	129	114	**115**
Pure and Three-Fourths	68	98	82	**83**

	Average Deviation	Pearson Coefficient	Thorndike Coefficient	Av.
Mulattoes and Quadroons	100	121	111	111
All Colored	85	109	97	97
Girls				
Pure Negroes	71	97	83	84
Three-Fourths	49	63	56	56
Mulattoes	92	113	102	102
Quadroons	56	57	57	57
Pure and Three-Fourths	68	89	78	78
Mulattoes and Quadroons	89	106	98	98
All Colored	71	89	81	80
Grades				
Pure Negroes	80	98	89	89
Three-Fourths	75	95	84	85
Mulattoes	91	109	100	100
Quadroons	45	49	47	47
Pure and Three-Fourths	82	102	93	92
Mulattoes and Quadroons	84	100	93	92
All Colored	84	102	93	93

TABLE LIV.

Maze Test—Variability of the Colored Subjects in Percentages of the Variability of the White—Richmond

	Average Deviation	Pearson Coefficient	Thorndike Coefficient	Av.
Boys—All Colored				
Touches	87	126	104	106
Distance	91	109	100	100
Girls—All Colored				
Touches	105	174	136	138
Distance	121	153	136	137
Grades—All Colored				
Touches	82	118	100	100
Distance	91	105	100	99

TABLE LV.

Cancellation Test—Variability of the Colored Subjects in Percentages of the Variability of the White—Richmond

	Average Deviation	Pearson Coefficient	Thorndike Coefficient	Av.
Boys—All Colored				
Omissions	172	89	122	128
Cancellations	103	105	104	104
Girls—All Colored				
Omissions	153	113	133	133
Cancellations	127	113	120	120
Grades—All Colored				
Omissions	167	106	133	135
Cancellations	103	94	98	98

The combined pure and three-fourths pure negroes, when compared with whites, have relative variabilities as follows in the Mixed Relations Test I, the Mixed Relations Test II and the completion test, respectively: Boys—84, 109 and 83 per cent.; Girls—104, 101 and 78 per cent.; Grades—96, 101 and 92 per cent. The figures for the combined mulattoes and quadroons show that they have the following relative variabilities in the three tests: Boys—98, 99 and 111 per cent.; Girls—121, 96 and 98 per cent.; Grades—103, 95 and 92 per cent. It is thus probable that the mulattoes and quadroons are slightly more variable than the pure and three-fourths pure negroes, but here again the results are not certain. Both classifications appear to have not far from the white variability.

When all classes of negroes are grouped together and compared with whites, they show the following relative variabilities in the three tests mentioned: Boys—107, 114 and 97 per cent.; Girls—113, 101 and 80 per cent.; Grades—102, 101 and 93 per cent. The colored subjects as a whole had a greater rather than a less variability than the white.

This last statement is reinforced by the figures from the maze and cancellation tests. In the maze test, the colored boys were 106 and 100 per cent. as variable as the white boys in touches and distance respectively; the colored girls were 138 and 137 per cent. as variable as the white girls in touches and distance; the colored grades were 100 and 99 per cent. as variable as the white in touches and distance. In the cancellation test, the figures showing the relative colored variability in omissions and cancellations, respectively, were: Boys—128 and 104 per cent.; Girls—133 and 120 per cent.; Grades—135 and 98 per cent. The negroes in these tests were more variable than the whites, all classes of colored subjects being grouped together.

In addition to these figures from Tables 52-55, attention should be called to those in Tables 39-43 and 46-50 as indications of the relative variability of the different sub-classes of negroes. These tables give the probable errors of the scores made by the various classes of negroes when compared with whites. The probable errors show a marked uniformity in being smaller for the darker-colored negroes and larger for those of lighter color. That is, they show that in the case of the darker negroes the separate age and grade groups varied less with respect to their own average difference from corresponding white age and grade groups. Now this greater constancy among the differences for the separate ages and grades of darker negroes might have been due to chance if it had occurred only infrequently. For example, if the scores of four white grades are 40, 50, 40 and 50, and the scores of four corresponding colored grades are 20, 30, 20 and 30, the differences between these grades will be 20, 20, 20 and 20, and the probable error will be zero. But if the four corresponding colored grades have scores of 30, 20, 30 and 20, the differences will be 10, 30, 10 and 30, and the probable error will be 5. The actual scores and the actual average differences are the same in the two cases, but a chance arrangement in the correspondence of the scores alters the probable errors. And if the difference from the whites of first the lighter and then the darker negroes had the smaller probable error, we could attach no significance to the fact. But the smaller probable error in the case of the darker-colored negroes occurs with a uniformity which cannot be ascribed to chance. And we must suppose that it is due to a greater constancy in the scores of the individuals within the darker age and grade groups themselves. This greater constancy of the individual scores would be reflected in the greater constancy of the separate group scores and hence in the smaller probable error of such scores. And consequently we have a further indication of the smaller variability of the negroes of comparatively pure blood.

On the whole, it appears that the pure negroes, the three-fourths pure negroes and the quadroons varied less than did the whites; that the mulattoes did not differ from the whites in variability; that the combined pure and three-fourths pure negroes and the combined mulattoes and quadroons had not far from white variability, and that the latter class varied slightly more than did the former; that the colored subjects of all classes together had a greater variability than the white. But these conclusions are only approximately certain. The average coefficients upon which they are based are not uniform in their import, and the separate coefficients taken by themselves are not more so. If we consider only the actual variabilities, the white are clearly more variable than the colored subjects, except in the cancellation test, and the sub-classes of negroes, particularly those of darker color, are much less variable than the negroes as a whole. It is interesting to note that the colored girls had generally a greater variability than the colored boys when compared with whites.

Figures 25-28 are inserted to show graphically the relative distribution of the two races in one test—the completion. This distribution is fairly typical of that found in the other tests. All classes of negroes are included. In the graphs the boys and girls are treated separately, but the elementary pupils are grouped together, as are the high school pupils.

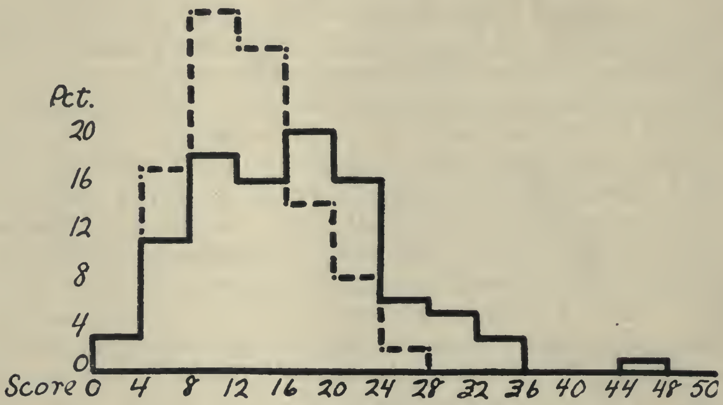

Fig. 25. Completion Test—Distribution of the Scores of White and Colored Subjects—Grammar-Grade Boys—Richmond.

The solid and the broken lines indicate the scores of the white and the colored subjects, respectively.

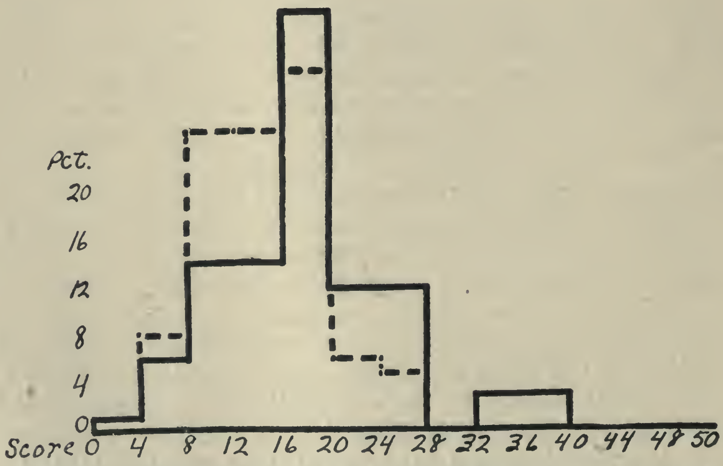

Fig. 26. Completion Test—Distribution of the Scores of White and Colored Subjects—Grammar-Grade Girls—Richmond.

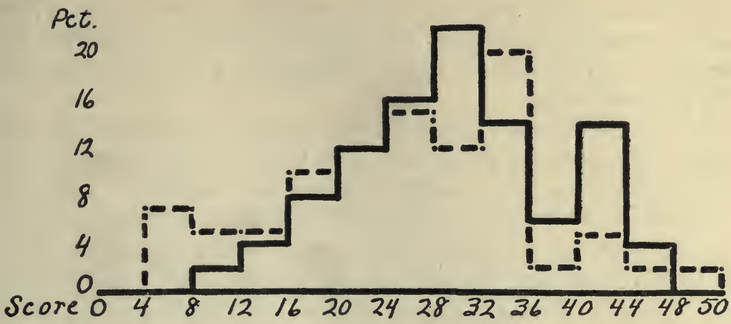

Fig. 27. Completion Test—Distribution of the Scores of White and Colored Subjects—High School Boys—Richmond.

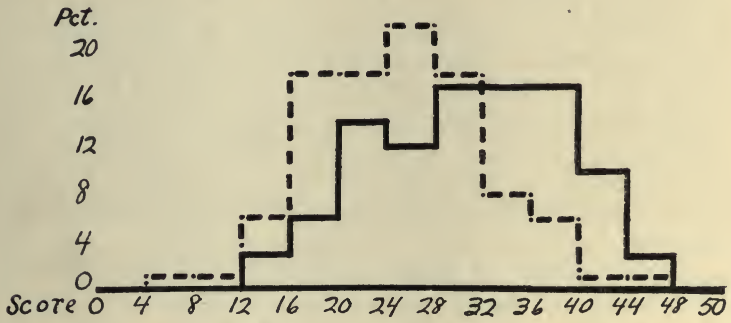

Fig. 28. Completion Test—Distribution of the Scores of White and Colored Subjects—High School Girls—Richmond.

This procedure is permissible on the ground that within either the elementary or the high school grades tested the pupils do not differ significantly from age to age, as was shown in Chapter III. The number of pupils obtaining a given score was in all cases reduced to a percentage of the total number in the distribution.

From the graphs it appears that the white elementary boys and the white elementary girls are probably more variable than the colored, but that the colored subjects, particularly the boys, are probably the more variable in the high school. But no certain conclusion as to racial variability can be reached. It appears more certain that the boys are more variable than the girls. Incidentally, attention may be called to the comparison of racial ability revealed by the graphs. They make plain the extensive overlapping of the scores of the whites and negroes. Even where there is a great difference between the average scores of the two races and where only a small percentage of the negroes reaches or exceeds the average of the whites, the overlapping is great and should not be overlooked.

It may finally be remarked with regard to the relative variability of whites and negroes, that it would not be at all surprising if groups of so-called negroes were definitely shown to be more variable than comparable groups of whites. For the groups that are generally called negroes are composed of individuals ranging from pure negroes to persons almost white, and it would be reasonable to suppose that such groups would vary more than would homogeneous white groups. They are not composed of one race but of two. Of course it may be that the variability of the negro race falls entirely within the extremes of variability of the white, but this would not offset the greater average deviation that would be caused by the relative tendency to bi-modality, or at least to flatness of distribution, in a mixed negro and mulatto group. This consideration should be taken into account in all studies of the variability of whites and negroes. It would be interesting and useful to know whether colored people, negroes and mulattoes together, vary as much as do whites. But this information would not inform us as to the relative variability of the white and negro races.

CHAPTER V.

CONCLUSION

By way of summary of the various considerations which have come to light in this study, we may say that the average performance of the colored population of this country in such intellectual work as that represented by the tests of higher capacity, appears to be only about three-fourths as efficient as the performance of whites of the same amount of training. It is probable, indeed, that this estimate is too high rather than too low. The groups of whites and negroes studied are not typical of the white and colored populations in general; their ability is undoubtedly considerably above the average. But the negroes were probably farther above their racial average than were the whites. If one were to test the capacity of the unselected masses of negroes, with their much smaller percentage of white blood, and make a comparison with unselected masses of whites, the results would almost certainly reveal greater racial differences than those found herein.

All of the experimental work which has been done has pointed to the same general conclusion. The bulk of it has shown a greater racial difference than that found in Richmond, and has been more comparable in its results with the findings recorded for Fredicksburg and Newport News. The opinions of the great majority of those who have come into contact with the negro, and the views of nearly all of those who have studied the question from standpoints other than experimental, are in substantial agreement with the quantitative evidence.

In the present state of the advancement of science it does not seem possible to make adequate tests of those vastly important qualities which are included in the feeling and dynamic, rather than in the intellectual, side of mental life. It is the common opinion that the negro differs more from the white in such traits than in intellect proper. His emotions are generally believed to be strong and volatile in their manifestations; whether this is due to their intrinsic nature or to a lack of restraint, is an untouched problem. Instability of character is ascribed to the negro, involving a lack of foresight, an improvidence, a lack of persistence, small power of serious initiative, a tendency to be content with immediate satisfactions, deficient ambition. But the evidence that such characteristics constitute a true racial difference cannot be called conclusive, and the psychological causes underlying them have not been adequately investigated. Along with high emotionality and instability of character, defective morality is held to be a negro characteristic. This is as subject to debate as are the other qualities, though it is apparently supported by social statistics.* It may be that the total circumstances of his life are such as would lead to immorality even were the negro possessed of the psychic nature of the white man.

On the other hand, while it is impossible to arrive at an exact knowledge of the relative amounts of such important but intangible traits in the two races, it must be said that the evidence of experience and observation cannot be disregarded. Such evidence is often wholly unscientific and worthless, but not always so. Strong and changing emotions, an improvident character and a tendency to immoral conduct are not unallied. They are all rooted in uncontrolled impulse. And a factor which may tend to produce all three is a deficient development of the more purely intellectual capacities. Where the implications of ideas are not apprehended, where thought is not lively and fertile, where meanings and consequences are not grasped, the need for the control of impulse will not be felt. And the demonstrable deficiency of the negro in intellectual traits may involve the dynamic deficiencies which common opinion claims to exist.

The available evidence indicates that in the so-called lower traits there is no great difference between the negro and the white. In motor capacity there is probably no appreciable racial difference. In sense capacity, in perceptive and discriminative ability, there is likewise a practical equality. It is in the central elaborative powers upon which thought more directly depends that differences exist, not in the simpler receptive and discharging functions. It seems as though the white type has attained a level of higher development, based upon the common elementary capacities, which the negro has not reached to the same degree. From the nature of the mental differences, one would infer that such neural differences as may be found will probably be mainly in the constitution of the cortical neurones, rather than elsewhere in the nervous system.

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*Statistics concerning the sexual immorality, as indicated by illegitimate births, of whites and negroes in the District of Columbia have recently been published by Ottenberg ('15). In 1912 and 1913 the total of all births reported to the Health Department was 13,910, of which number 1374, or approximately 10 per cent. were illegitimate. There were four times as many illegitimate births of colored as of white children reported, and yet the colored population was only about one-half as large as the white. Statistics showing the very much larger percentage of negroes than of whites convicted of crime are too well known to require quotation here.

While the intellectual performance of the general colored population is approximately 75 per cent. as efficient as that of whites, this figure is not true for different classes of negroes. It is probably correct to say that pure negroes, negroes three-fourths pure, mulattoes and quadroons have, roughly, 60, 70, 80 and 90 per cent., respectively, of white intellectual efficiency. If it were possible to distinguish these four classes of negroes so accurately as to avoid overlapping, it is probable that the differences revealed by tests would be greater rather than less than those indicated by the figures.

The educational significance of the available facts is difficult to determine. The negro's intellectual deficiency is registered in the retardation percentages of the schools as well as in mental tests. And in view of all the evidence it does not seem possible to raise the scholastic attainment of the negro to an equality with that of the white. It is probable that no expenditure of time or of money would accomplish this end, since education cannot create mental power, but can only develop that which is innate.

The movement toward industrial education for the negro finds sanction in the studies of his psychology. Without great ability in the processes of abstract thought, the negro is yet very capable in the sensory and motor powers which are involved in manual work. And economy would indicate that training should be concentrated upon those capacities which promise the best return for the educative effort expended. Social conditions, of course, have been the main incentive to the growth of industrial education among negroes, and in themselves they are sufficient reason for emphasizing an intensely practical training. But the mental nature of the negro gives reason for believing that this sort of education is the only one which will avoid great waste. Diminishing educational returns will be more serious in the intellectual than in the industrial education of the negro.

There is need of experiment to determine the relative ability of colored and white persons in the intelligent handling of concrete materials. All of the experiments so far undertaken have dealt with thought material as represented by words rather than by objects. Tests which involve mechanical manipulations have not been tried. It is possible that reasoning based upon objects present to sense may not correlate highly with reasoning based upon the mental representations of objects, and that the negro may therefore more nearly approach the white in the former than he does in the latter sort of thinking. The writer expects to undertake a series of experiments upon the comparative intellectual ability of the two races in mechanical tests, and if the difference between them is less than that revealed by tests of a more literary nature, additional sanction will be given to the reasonableness of industrial education.

But while it thus appears that for the colored population as a whole a manual is more practicable than a literary education, it must not be overlooked that there are individual colored persons of great ability. The widely held doctrine that the negro's mental growth comes to a comparative standstill at adolescence does not find corroboration in the results of tests. The groups so far tested, indeed, show that after adolescence the negro more nearly approachs the white than before. This is probably due to the fact that the adolescent negroes tested are a more closely selected group than those who have not reached adolescence. The adolescent negroes in the schools have more white blood in them. And racial differences at adolescence may exist in the feeling and dynamic sides of mental life, which have not been tested. If there are such differences they will most likely appear just here. But so far as has been demonstrated, the negro's intellectual development proceeds as rapidly after puberty as does that of the white. Then, too, the variability of the negroes and the overlapping of ability in the two races, make it necessary to expect very able colored persons to be found in every large group. In the main, the most capable colored individuals will be mulattoes, although there are fewer mulattoes than pure negroes.

Since comparisons between races are frequently made in terms of the number of eminent men produced by each, it is interesting to make a rough computation as to the number of pure negroes, mulattoes and whites that may be expected to demonstrate great ability in the United States. This computation lays no claim to other than approximate validity. It is based upon the "law of deviation from an average" as employed by Francis Galton ('92, p. 22 ff.), and in making it the variability of each class of the population is considered as being the same. Of course, if the variability of pure negroes is less than that of whites, as is probable, the number of very able negroes will be less than is indicated by the following figures.

We may take as our standard of eminence the one chosen by Galton, viz., attainment so great that it is reached by only one man in 4300. In each million men there are 248 persons of this standing. Now there are approximately 18,000,000 white men, 1,600,000 pure negro men and 400,000 men who are mulattoes in this country. Consequently, if all three classes have the same ability, there will be 4464 eminent white men, 397 eminent pure negroes and 99 eminent mulattoes.

But if we assume that pure negroes average 75 per cent. of white ability and that mulattoes average 87.5 per cent. of white ability, we find the following situation growing out of the law of deviation from an average.* In a million of each class of men, there will be 248 whites, 15 mulattoes and 1 pure negro who will attain the above-mentioned degree of eminence. Considering the number of these three classes in the total population, there will be 4464 eminent whites, 6 eminent mulattoes and 2 eminent negroes in the United States.

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*To carry out the computation based upon this assumption it is necessary to postulate a zero point of ability, and the capacity of the lowest idiot is taken as this zero point. That this may be done without violence to the facts is indicated by the descriptions of idiocy given in works on mental deficiency. Thus Tredgold ('08) writes of profound idiots that their brief existence may almost be called vegetative. They are devoid of instincts, they lie huddled in an ante-natal posture, food must be placed in their mouths, and their life activities hardly extend beyond respiration, assimilation and excretion. "They have eyes, but they see not; ears, but they hear not; they have no intelligence and no consciousness of pleasure or pain; in fact, their mental state is one entire negation." ('08, p. 171).

These figures are suggestive. If we take it that there are 4464 eminent white men in America, there are certainly not 397 pure negroes and 99 mulattoes of the same degree of eminence. There are more nearly 6 mulattoes and 2 pure negroes to 4464 eminent whites. Definite figures are not obtainable, but such lists of men of achievement as have been compiled accord with the latter set of figures far more closely than with the former.

Of course it may be held that social conditions make it impossible for colored ability to assert itself. There may be potentially eminent men among the negroes who are not able to attain their commensurate achievement on account of environmental conditions. On the other hand, it may be said that the best opinion, as that of Galton, holds that eminence is independent of circumstance; that innate power can be neither crushed nor created by adverse or favorable influences. And it may be further contended that ability among negroes is all the more readily recognized just because of their generally low level of racial attainment. A man of mark among them stands out becauuse of his rarity, and his opportunities are increased because of this recognition.

As an indication of the greater ability of mulattoes than of pure negroes, it may be remarked that such lists as we have of colored leaders, e.g., those quoted in Chapters I and IV, show a larger proportion of men of mixed than of unmixed blood. And this despite the fact that there are probably four times as many pure negroes as mulattoes in the country.

Although the available facts are very few and inexact, such as they are they serve to justify rather than to controvert the deductions from the law of variability. And in so far as the deductions are borne out, the assumed racial inequality upon which they are based is confirmed.

There are few more controversial subjects than that of the outlook for the negro race in America, and it is not within the province of this monograph to attempt a discussion of the topic. But it may not be out of place to mention certain considerations that have presented themselves. Conclusions concerning the negro's possibilities in this country are frequently drawn from a study of the various small negro republics, such as Haiti, Santo Domingo and Liberia, and opinions so arrived at are not without their value. Yet there are differences between the position of the American negro and that of the negro in the isolated states in question. It should be noticed that the number of American negroes is larger than the number in any of the negro republics. Progress depends upon the size of a group as well as upon its average capacity. Other things being equal, the larger group will produce more very able individuals, and such individuals, as was previously pointed out, furnish the ideas and the inspiration for the whole group. And the American negro is in much closer contact with the white race than are the inhabitants of the independent negro countries. This contact gives him the advantage of white encouragement, achievement, example and control, and enables him to appropriate to his own use the products of white genius. Races, or nations, between which there is free intercommunication make greater progress than do isolated peoples, for the results of the ability of one race are more readily taken over and incorporated into the life of the other. Hence we may reasonably expect the colored people of America to show a higher type of civilization than those of their race who are differently situated, even though the native ability of the negro is everywhere the same.

In this connection Thorndike writes as follows: "The origination of advances in civilization is a measure of ability, but the abilities that have originated them have probably been confined to a very few men. A race that originated none of them may now possess them all. Even if a race has been completely isolated, its civililzation has been originated by only a few of its members; and the chance of men of great gifts being born is the result not only of the central tendency of a race and its variability, but also of its size. Other things being equal, there is a far greater chance of the birth of a man of great ability in a tribe of a million than in one of a thousand. Since one such man may add to the knowledge and improve the habits of the entire group regardless of its size, civilization will progress more rapidly in large than in small groups, in a condition of isolation.

"The civilized races have not remained isolated and have got most of their civilization from without. Of ten equally gifted races in perfect intercourse each will originate only one-tenth of what it gets. The original nature of the Germans of to-day is not much different from that of their ancestors in the time of Tacitus, and their progress in the meantime is not properly theirs, but that of the European world and its American colony, each of whose racial stocks has added something to the common fund." ('10, p. 67).

But probably the greatest difference between the American negro and the members of his race in the relatively isolated negro communities elsewhere, will eventually be found in the greater amount of white blood which the American negro will possess. In the course of generations, if the present or a similar rate of white admixture continues, there will be few if any pure negroes remaining in the United States. The whole of our colored population will be mulatto, and as time passes the proportion of white blood will increase. This will be inevitable from the fact that white blood once infused into the negro community will remain there and be continued by intermarriage among the negroes from generation to generation. The white blood in a mulatto does not return to the white race through intermarriage; the white stock will remain pure. It is among the negroes that a mulatto's white inheritance is diffused. Such a continued raising of the amount of white blood in the negroes is of course dependent upon a continuance of some degree of race intermixture; but there is no valid reason for believing that intermixture will wholly cease.

This consideration will in time work a great change in the race problem in America, and it may both simplify and complicate the interracial situation. On the one hand, the negro will have greater ability, and there will be less difference between the races. The standard of colored achievement will be higher. But on the other hand, race friction may be increased. The mulatto is not as tractable or as submissive to white domination as is the pure negro. He thinks and feels more nearly as does the white man. And he cannot be content with the social restrictions that are thrown around him. In our own time these tendencies seem to be already evident. The very considerable progress that the negro has made has been in large measure due to mulattoes. And it is mainly the mulattoes who have so largely done away with that type of negro which was content to regard itself as the natural dependent of the white. It seems probable, indeed, that the excessive criminal and immoral tendencies sometimes charged to the mulatto may be due, if they exist at all, to the fact of his recognition of his ability and his resentment at the position of inferiority in which he is placed.

The statement is frequently made that mulattoes are of a less hardy physical nature than are pure negroes, and that their death rate is therefore higher. There is no reliable evidence of this. On the contrary, there is a not unfounded opinion that half-breeds from colored Asiastic and white European stock are longer lived than the original races from which they spring.

There is evidence that the colored population as a whole has a considerably higher death rate than the white. In the U. S. Census ('13) are given the death rates for different classes of the population in the area of registration. This area embraces twenty-three states in the North and the West, and certain cities but no states in the South. The death rate for native whites, per 1000, is 15.7; for foreign-born whites it is 18.9; for negroes it is 25.0. In Washington, D. C., the white death rate is 15.5; the colored is 26.6 In Baltimore, the white death rate is 16.2; the colored is 30.9. In New Orleans, the white death rate is 16.6; the colored is 31.2. At all ages the colored death rate is the higher. In the Virginia cities, Alexandria, Danville, Lynchburg, Norfolk, Petersburg, Richmond and Roanoke, the average death rate for both races combined is 20.6. But in these cities there are 3502 deaths of negroes to 3429 deaths of whites, and yet the colored population is only about one-half as numerous as the white. The life insurance companies recognize this greater mortality among the negroes. The ratio of actual to expected deaths among negro men is reported as follows in the Medico-Actuarial Mortality Investigation ('13): Negro ministers, teachers and other professional men, 137 per cent.; all other colored men, 147 per cent. It may be added that the ratio for North American Indians is 124 per cent.

The greater colored mortality is probably due to a number of causes. The fact that the higher class of negro men has a lower death rate would indicate that the insanitary conditions of negro life are a factor. And the nature of the most prevalent diseases among the negroes would also point to this. Tuberculosis, for instance, is the cause of death for 405.3 negroes and 126.2 whites per 100,000 population of each race. As better living conditions are established among our colored population it is reasonable to suppose that their death rate will not be relatively so much greater than that of the whites. But on the other hand, it is also probably true that the natural constitution of the negro is a factor in producing his greater mortality in America.

However this may be, it is a fact that the negroes in this country have increased less rapidly than the whites in recent years in proportion to their numbers, despite the general opinion that they are more prolific in offspring. In the country at large, between 1900 and 1910, the native whites of native parentage increased 20.9 per cent.; the native whites of foreign or mixed percentage increased 20.8 per cent. But the negroes increased only 11.2 per cent., and in the South the percentages of increase for the two races are approximately the same as those for the nation.

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Appendix—The Tests

Mixed Relations Test I.		*Mixed Relations Test II.*	
Eye—see	Ear—	Good—bad	Long—
Monday—Tuesday	April—	Eagle—bird	Shark—
Do—did	See—	Eat—bread	Drink—
Bird—sings	Dog—	Fruit—orange	Vegetable—
Hour—minute	Minute—	Sit—chair	Sleep—
Straw—hat	Leather—	Double—two	Triple—
Cloud—rain	Sun—	England—London	France—
Hammer—tool	Dictionary—	Chew—teeth	Smell—
Uncle—aunt	Brother—	Pen—write	Knife—
Dog—puppy	Cat—	Water—wet	Fire—
Little—less	Much—	He—him	She—
Wash—face	Sweep—	Boat—water	Train—
House—room	Book—	Crawl—snake	Swim—
Sky—blue	Grass—	Horse—colt	Cow—
Swim—water	Fly—	Nose—face	Toe—
Once—one	Twice—	Bad—worse	Good—
Cat—fur	Bird—	Hungry—food	Thirsty—
Pan—tin	Table—	Hat—head	Glove—
Buy—sell	Come—	Ship—captain	Army—
Oyster—shell	Banana—	Man—woman	Boy—

Completion Test

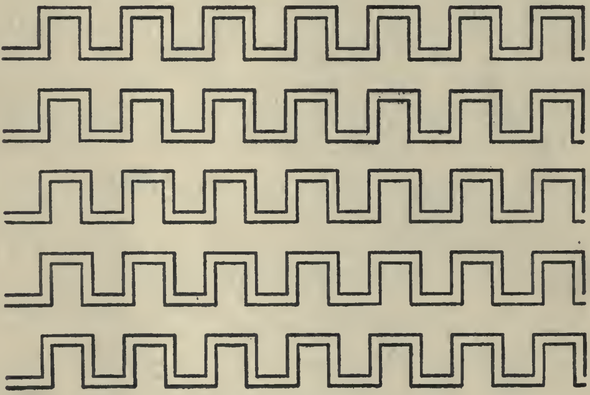
On each line of dots write the word which makes the best meaning.

23. The poor baby .... as if it were .... sick.
24. The .... rises .... the morning and .... at night.
25. The child .... river .... was drowned.

26. Boys who play .... mud get their hands ....
27. It is good to hear .... voice .... friend.
28. The poor little .... has .... nothing to ...... ; he is hungry.
29. Boys and .... soon become .... and women
30. The boy who .... hard .... do well.
31. She .... if she will.
32. One's .... do .... always express his thoughts.
33. Very few people .... how to spend time and .... to the best advantage.
34. It is a .... task to be kind to every beggar .... for money.
35. Brothers and sisters .... always .... to help .... other and should .... quarrel.
36. Worry .... never improved a situation but has .... made conditions ....
37. Men .... usually more .... to do heavy work .... women.
38. .... weather usually .... a good effect .... one's spirits.
39. If a person injures one by ...., without having intended any ...., one should .... insulted.
40. A shelter .... the weather is .... appreciated on a .... day.
41. It is very .... to become .... acquainted .... persons who .... timid.
42. The best advice .... usually .... obtained .... one's parents.

43. A home is .... merely a place .... one .... live comfortably.
44. The sun is so .... that one can not .... directly .... causing great discomfort to the eyes.
45. To .... many things .... ever finishing any of them .... a .... habit.
46. .... are imes in the .... of almost .... of us when we .... for a long life.
47. Children should ...... that after all nobody is .... to care much more .... their success than .... parents.

Maze Test—(three-fifths original size).



Cancellation Test

OYKFIUDBHTAGDAACDIXAMRPAGQZTAACVAOWLYX
WABBTHJJANEEFAAMEAACBSVSKALLPHANRNPKAZF
YRQAQEAXJUDFOIMWZSAUCGVAOABMAYDYAAZJDAL
JACINEVBGAOFHARPVEJCTQZAPJLEIQWNAHRBUIAS
SNZMWAAAWHACAXHXQAXTDPUTYGSKGRKVLGKIM
FUOFAAKYFGTMBLYZIJAAVAUAACXDTVDACJSIUFMO
TXWAMQEAKHAOPXZWCAIRBRZNSOQAQLMDGUSGB
AKNAAPLPAAAHYOAEKLNVFARJAEHNPWIBAYAQRK
UPDSHAAQGGHTAMZAQGMTPNURQNXIJEOWYCREJD
UOLJCCAKSZAUAFERFAWAFZAWXBAAAVHAMBATAD
KVSTVNAPLILAOXYSJUOVYIVPAAPSDNLKRQAAOJLE
GAAQYEMPAZNTIBXGAIMRUSAWZAZWXAMXBDXAJZ
ECNABAHGDVSVFTCLAYKUKCWAFRWHTQYAFAAAOH

E.

THE EFFECT OF DISTRACTION ON REACTION TIME

WITH SPECIAL REFERENCE TO

PRACTICE AND THE TRANSFER OF TRAINING

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PREFACE

This research work was undertaken in the psychological laboratory of Columbia University. To Professors Cattell and Woodworth, and Dr. Poffenberger I owe a debt of gratitude for encouragement and helpful criticism. Grateful acknowledgment is also given Professors Thorndike and Strong, and to the subjects who so willingly gave their time and many valuable suggestions.

THE EFFECT OF DISTRACTION ON REACTION-TIME

CHAPTER I

STATEMENT OF THE PROBLEM

An unwelcome influence which has played a more or less important rôle in reaction experiments has been the factor of such accessory stimuli as noises and similar disturbances. The exact influence of this factor has never been measured, although several experimenters[1] have spoken of its presence and have tried to eliminate its influence from the laboratory, or disregard the data obtained when any disturbance was present.

But it is important to measure the influence of this factor. Such measurements may very well form the basis for conclusions relating to business, social, and educational life.

Although any extrinsic influence used in the laboratory is purer, simpler, and more controlled than any similar condition which may arise in everyday life, yet the effect upon the physical and mental processes will be the same, relatively. However, the important factors of interest, emulation, satisfaction, ideals, etc., must be considered in the complex everyday life as influencing results.

It is the purpose of this investigation (1) to determine the effect of a stimulus, which occurs at a definite time before the stimulus to which the subject must react, on the reaction time to the latter stimulus; (2) to determine whether a subject by practise can finally ignore the distraction stimulus to the extent that no noticeable effect occurs in the reaction time; (3) to determine the effect of reacting under one set of distracting conditions on the ability to react under other conditions; (4) to show the effect of practise on simple reaction time and on reaction time under distraction.

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[1] Wundt, "Physiological Psychology," **2**, p. 355, 1887. Todd, "Reaction to Multiple Stimuli," Archives of Psychol., 1912, No. 21, p. 56.

Note.—As the work by Todd has recently reviewed the work on reaction-time experiments only such references will be made herein which are necessary to substantiate methods, conclusions, etc. A more recent study has been made by Henmon, "Psychol. Researches of James McKeen Cattell," Archives of Psychol., No. 30, 1914.

Feré, "Sensation et Mouvement," 26–50, 1887.

Guisseppi Corberi, *Rivisti di Psicologia*, 1914, **9**, 452, 460, 480.

Briefly stated, the problem concerns the effect of distraction on reaction time, and the effect of practise in dealing with distractions.

Other subordinate problems will be treated in their proper sequence. A statement of these minor problems is made on page 26.

Reaction experiments were used as the basis of this investigation, as the processes involved in the reaction experience are fundamental to behavior in its complexer forms.

CHAPTER II

HISTORY OF REACTION-TIME WITH RELATION TO DISTRACTION

I. General Survey

To summarize briefly what different experimenters have meant by distraction is difficult. Some experimenters have found a certain stimulus to be a real distraction in some particular cases, but when other experimenters have used the same distracting stimulus under different conditions the results have often been contrary to previous results. Thus the power of a stimulus to distract the attention does not seem to remain constant.

If the distraction is often repeated, we grow accustomed to it, and have little difficulty in meeting the demand which it lays upon us.[1] Or the distraction may be so monotonous from the very beginning of its introduction that it loses its distraction power very soon.[2]

1. *Definition.*—Because of these conditions much confusion has arisen concerning the meaning of a distraction. We commonly believe that a distraction is not effective so long as maximum attention can be given to the main stimuli or task. This view considers a distraction as something which has enough influence to divide or distract, or divert the attention from some task in the focus of consciousness. If the maximum attention can be given to the task the distraction is not effective.

2. *Methods of Study.*—The study of the relation of distraction to attention has proceeded along two lines. One is the single task method, the other the double task method.[3] They have frequently been called the distracting method, or the method of distracted attention,[4] and the method of simultaneous activities or distributed attention. In the first case the attention is distracted, in the second case divided.

By the distraction method the subject attends to a definite task while some distraction is introduced. The purpose of the distraction is to reduce the degree of attention given to the main task.

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[1] Külpe, "The Problem of Attention," *The Monist,* 1903, **13**, 45.

[2] Swift, *Amer. Jour. Psychol.*, 1892–3, **5**, 10.

[3] Geissler, *Amer. Jour. Psychol.*, 1909, **20**, 486.

[4] Wundt, "Grundz. d. Physiol. Psychol.," 1st ed., 745–49, 1874. Obersteiner, *Brain,* 1879, **1**, 447 f. Külpe, *The Monist,* 1903, **13**, 44, 45.

In the second method distraction may or may not be present. Two mental processes are involved which are supposed to occupy simultaneously the focus of consciousness.

Although this classification is generally accepted some confusion may arise concerning the notion of attention.[5] Distraction will mean different things when concerned with different views of attention. Distraction or division of the attention may thus mean a reduction in the concentration. More things have come into consciousness to which attention must be directed, thus there is a greater spread, or less concentration. It may mean a decrease in clearness,[6] or it may even mean a decrease in vividness, or degree of attention[7] or a lessened excitability of all the processes concerned in the apprehension and reaction to the contents of perception.[8]

II. Historical Survey

Obersteiner used reaction time as a basis for the measurement of attention.[9] His distractions were a music box, a tolerably strong induction current for cutaneous stimulation, and a kaleidoscope with changing figures for visual distraction. When the music ceased just before the stimulus was presented to which a reaction was made the reaction time was increased. All the distractions affected the simple, muscular reactions. As the time between the distractions and the stimulus to which the reactions were made was not carefully controlled it is difficult to interpret his results. Nor were the distractors uniform in their influence for they affected the various subjects differently. Wundt also noticed that when a noise occurred just before the stimulus to which a reaction must be made the reaction time was increased; if the noise and the stimulus occurred simultaneously there was no noticeable effect upon the reaction time.[10]

Cattell, in his investigation of the influence of degrees of attention upon reaction time, used three metronomes as distractions. When these metronomes were allowed to beat and ring rapidly the reaction time to a light stimulus was slightly increased, but the reaction time to a sound was not changed by the disturbance. When the subject was busied by beginning with any number and adding 17 after 17 to it, the time of the reactions was greatly lengthened, as he could not attend so well to the movements involved in making the reaction.[11]

---

[5] "Popular psychology . . . confuses in its idea of attention that of a faculty, the operation of which produces certain changes in the mental life; that of an activity—the activity of remarking, noticing, observing—always diverted upon some definite content which is the immediate occasion of its existence; and, lastly, that of a state, in which we continue for a longer or shorter time unaffected by changes in the contents of our consciousness."—Külpe, *The Monist*, 13, 42.

[6] Lipps, "Grundtatsachen d. Seelenlebens," p. 134, 1883.

[7] Külpe, "Outlines of Psychology," 441, 1895.

[8] O. Külpe, "The Problem of Attention," *The Monist*, 1903, 13, 48.

[9] *Brain*, 1879, 1, 447 ff.

[10] "Physiol. Psychol.," 1st ed., 447 f., 1879; 2d ed., 243, 293, 355, 1887; 5th ed., Ch. III., 1903.

Bertels used a light as a distraction and another light for a stimulus to which the reaction was made. The distracting light, however, acted as a preparatory or warning signal; thus it was in no sense a true distractor. The experimenter thought the interval of $2\frac{3}{8}$ seconds between the two lights was especially favorable for reacting. Multiples of this period were also favorable.[12]

Swift,[13] in a variety of experiments, found the reaction time to be increased by distraction, whether the distraction occurred in the same sense as the stimulus to which reaction was made, or in a different sense; and whether the subject's attention was directed towards the reaction or towards the distraction. Some of his results follow.

The subject reacted to the sound of a falling ball, and was disturbed by a metronome beating 120 times per minute. In one series his attention was directed towards the reaction, in another series towards the metronome. The reaction times, in σ, were as follows:

Attention to reaction 122, M.V., 12; control series, 103, M.V. 9.
Attention to metronome, 158, M.V., 14; control series, 110, M.V., 7.

The reaction time was slowed in each case, but more when attention was directed to the metronome than when it was directed towards the reaction.

Again, the subject reacted to the flash of a Geissler tube, and was disturbed by flashes of light reflected in a mirror, through a hole in which the light of the Geissler tube appeared. The number of disturbing flashes varied, as shown in the following table:

Reaction without Distraction				*Reaction with Distraction*			
Stimulus	*Time*	*M.V.*	*Number*	*Kind of Distract.*	*Number*	*Time*	*M.V.*
Light.....	143σ	10σ	100	60 flashes per min.	120	195σ	14σ
				120 flashes per min.	120	197	13
				180 flashes per min.	120	190	16
				540 flashes per min.	100	171	15

[11] *Mind*, 1886, 6, 237, 238, 242.

[12] "Versuchen über die Ablenkund der Aufmerksamkeit," Dorpat, 1889. (Thesis.)

[13] "The Disturbance of the Attention," *Amer. Jour. Psychol.*, 1892–3, 5, 1–19.

The following table gives the choice reactions to the sound of a falling ball. The disturbance was a definite number of ticks per minute of a metronome.[14]

Reaction without Distraction			
Stimulus	*Time*	*M.V.*	*Number*
Sound	103σ	9σ	100

Reaction with Distraction			
Kind of Distraction	*Number*	*Time*	*M.V.*
40 ticks of metronome per min.	100	206σ	18σ
80 ticks of metronome per min.	100	210	19
120 ticks of metronome per min.	90	191	18
160 ticks of metronome per min.	100	208	19
200 ticks of metronome per min.	100	206	17

When the disturbance was 180 flashes of light each minute and the subject was required to react by making a choice between two movements in response to either a red or an olive light the results were as given below:

Reaction with no distraction: 258σ, M.V., 23σ, No. of Reactions, 10.
Reaction with distraction 273σ, M.V., 25σ, No. of Reactions, 110.

When the subject reacted to the auditory stimulus the time was 123 σ, M.V., 8 σ, No. of reactions, 80. When he reacted to the same stimulus but with the flashes of light as a disturbance the results were as follows:[15]

Number of Flashes of Light	*Time*	*M.V.*	*No. of Reactions*
60	160σ	13σ	100
120	141	9	100
180	148	11	100

When the subject reacted to the flash of the Geissler tube and the disturbance was the ticking of the metronome the effect was as follows:

Number of Ticks	*Time*	*M.V.*	*No. of Reactions*
60	176σ	10σ	100
120	190	12	100
180	174	11	100

The average of one hundred reactions to the same stimulus without the distraction was 159 σ, M.V., 10 σ.[16]

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[14] Swift, *op. cit.*, pp. 5 and 8.

[15] Swift, *op. cit.*, p. 14.

[16] Swift, *op. cit.*, p. 15.

Drew attempted to measure the attention by varying its intensity.[17] Thus he arranged a series of increasing degrees of complexity which should make greater and greater demands on the mind, until the attention should pass from a fully concentrated state to a completely distracted state. But in this he was not very successful. He remarks that although his figures are in substantial agreement with those of other experimenters who worked under like conditions they are not satisfactory. The failure to obtain satisfactory results seems to be due to the great diversity of the material with which he worked and the presence of numerous uncontrolled influences.

The distractions consisted of:

1. Reading a text
    - (*a*) silently,
    - (*b*) aloud.
2. Naming letters
    - (*a*) in direct order in the text,
    - (*b*) in reverse order,
    - (*c*) on a drum, seen one at a time; the fixation of one letter seen through a slit.
3. Multiplication, *e. g.*, 6 x 19, etc.

The stimuli were given

1. By a fall apparatus and consisted of:
    - (*a*) letters,
    - (*b*) colors,
    - (*c*) diagrams,
    - (*d*) factors to be multiplied,
    - (*e*) numbers from one to ten.
2. Orally:
    - (*a*) factors to be multiplied,
    - (*b*) numbers from one to ten.

The reactions were made on a five- and ten-finger keyboard and with a mouth key. Drew states that greater stress was laid on the introspective observations made during the course of the experiments than upon the chronometric data obtained.

The effect of a disturbance on both the reaction-time and the time required to make a definite movement was determined by Moore.[18] His subjects reacted to the sound of a sound hammer.

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[17] *Amer. Jour. Psychol.*, 1895, 7, 533, 534.

[18] "Reaction-time and Movement," *Psychol. Rev. Mon. Sup.*, 1904–5, 6, 1–86.

The distractions were:

1. The process of addition.
2. Sensory stimuli:
    - (*a*) a continuous noise made by the interrupter of an induction coil,
    - (*b*) The noise of this coil accompanied by a slight shock received by holding the electrodes in the hand. This shock was not painful.
    - (*c*) An intermittent sound made by a metronome beating seconds.
    - (*d*) A very loud warning signal for reaction.

His results are summarized in the accompanying table.

REACTIONS TO AN AUDITORY STIMULUS (MOORE[19])

When the Disturbance Was the Continuous Sound on the Induction Coil

Subject	*Simple Reaction Time*	*M.V.*	*Reaction-Time with Dist.*	*M.V.*
A.....	164σ (13)	18σ	202σ (9)	36σ
			162 (13)	11
	168* (12)	20	169 (9)	9
	160 (12)	14	166 (12)	17
B....	145 (13)	16	179 (12)	17
C....	151 (18)	18	164 (12)	17
	156 (13)	17	169 (12)	11
D....	191 (12)	26	162 (12)	12
	170 (13)	16	165 (13)	13

When the Disturbance Was the Sound of an Induction Coil Accompanied by a Continuous Electric Shock

Subject	*Simple Reaction Time*	*M.V.*	*Reaction-Time with Dist.*	*M.V.*
A....	146σ (14)	17σ	177σ (12)	23σ
			166 (10)	18
			173 (13)	18
			172 (12)	13
C....			172 (12)	8
D....			212 (10)	45
			232 (14)	34
			173 (12)	16

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[19] *Op. cit.*, 50–53.

* 168σ becomes 159σ if a very long reaction, 266σ, is excluded.

When the Disturbance Was a Metronome Beating Seconds

B....	158σ (8)	39σ	166σ (11)	28σ
	164 (9)	30		
D....	148 (12)	16	240 (9)	30
			190 (12)	20
	164 (12)	27	179 (11)	20

When a Loud Warning Signal Preceded the Reaction

A....	129σ (9)	16σ	154σ (26)	19σ
			153 (34)	19
	180 (10)	27	166 (26)	32
			158 (38)	17
B....	147 (11)	14		
C....	142 (13)	14		

The figures in parenthesis indicate the number of cases.

Moore concludes that the effect of a continuous noise made during a series of experiments by the interrupter of an induction coil was to lengthen the reaction-time, and also to a slight extent the movement-time.[20] "The effect of this same noise accompanied by a slight shock, received by holding the electrodes in the left hand, was to lengthen still more the reaction-time. In like manner, the movement made under the influence of two disturbances was as a rule slower than that executed during a single disturbance. The effect of the metronome beating seconds was to lengthen the reaction-time but there was no apparent effect on the movement-time. A very loud signal for reaction was followed by a quicker movement than that of reactions made with the usual tap of the hammer."

Breitweiser investigated the state of attention in the interval between the "Ready!" signal and the stimulus for reaction. The subjects were required to add as rapidly as possible a printed column of figures, but to cease when the "Ready!" signal was given and be ready to react to the sound of the sound hammer. The adding was then to be resumed till the next "Ready!" signal was given. The results showed a general slowing of reactions after all intervals (1–10 seconds), but practise quickly increased the speed. When the adding was not interrupted but continued after the "Ready!" signal was given. The results showed a general slowing of reactions (1–10 seconds), but practice signal and the reaction made "on the side" the time of reaction was further increased.[21]

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[20] Moore, p. 56.

[21] Breitwieser, "Attention and Movement in Reaction-time," ARCHIVES OF PSYCHOL., 1911, No. 18, pp. 19, 31, 32.

Todd used light as a stimulus but preceded it by an electric shock or a sound and an electric shock. The stimuli were separated by a definite interval and reaction was always to the light which occurred last. Four intervals were used between the stimuli as follows: 360 σ, 180 σ, 90 σ, 45 σ. The results of 200 reactions for each interval are given below.[22]

Reaction to a Light Stimulus when Preceded by a Sound and an Electric Shock

Interval	*Time*	*M.V.*
360σ	201.5σ	8.8σ
180	208.4	18.6
90	176.9	8.0
45	168.5	7.7

Reaction to a Light Stimulus when Preceded by an Electric Shock

360σ	195.1σ	5.7σ
180	220.3	6.3
90	174.4	7.8
45	169.5	10.1

The simple reaction-time, when no preceding stimulus was present, was 185.8 σ, and 175.6 σ, for the two subjects employed.

The 180 σ interval seems especially favorable for the distraction influence. The author states that the sound produces a disturbance which partially passes away during the interval of 360 σ which follows. However, the electric shock occurs before the excitement has entirely passed and starts another excitation which does not pass away before the light stimulus occurs to which the subject reacts. "Thus, the reaction to light is partially inhibited by the inertia of the previous disturbance." The full motor discharge that is usually set off by the light when used alone has been somewhat drained off in the other disturbances, and the reaction time is thus longer than when light appeared alone. The inhibitory effect is similar for the interval of 180 σ. But the intervals of 90 σ and 45 σ cause a decided decrease in the reaction-time not unlike the decrease caused by increasing the intensity of the stimulus or of using simultaneous stimuli. All the figures which the author presents are not in harmony with his theory of explanation, for the time of reacting with the 180 σ interval is longer than when the 360 σ interval was used.

The following bibliography deals with distraction but without relation to reaction-time.

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[22] Todd, "Reaction to Multiple Stimuli," ARCHIVES OF PSYCHOL., 1912, No. 21, pp. 53, 4, 6. Also, Table XVII., p. 38.

Distraction as a factor in motor phenomena has been observed by:

Loeb, *Archiv f. d. ges. Physiol.*, **39**, 1886.
M. Feré, Sensation et Movement, 1887.
M. Feré, *Jour. de l'Anatomie et de la Physiologie*, 1901.
Bowditch and Warren, *Jour. Physiol.*, **11**, 25–64, 1890.
Binet, *Rev. Philos.*, **19**, 1890.
Bliss, *Yale Studies*, **1**, 1893.
Hofbauer, *Pflüger's Archiv f. d. ges. Physiol.*, **68**, 546–59, 1897.
Henri, *L'Année Psychol.*, **3**, 1897.
Welch, *Amer. Jour. Psychol.*, **1**, 283–306, 1898.
Sancté de Sanctis, *Zeits. f. Psychol.*, **17**, 1898.
Cleghorn, *Amer. Jour. Physiol.*, **1**, 336–345, 1898.
McDougall, *Brit. Jour. Psychol.*, 1904.
Peter, *Archiv f. d. ges. Psychol.*, **8**, 1906.
Corberi, *Rivista de Psicologia*, Anno. 9.=N. 5, 1913.
Bogardus, *Amer. Jour. Sociol.*, **17**, 1912.
Billings, *Psychol. Rev.*, **11**, No. 2, 1914.

Distraction as a factor in the study of attention has been referred to as follows:

Münsterberg, *Psychol. Rev.*, **1**, 1894.
Münsterberg, *Zeits. f. Psychol.*, **1**, 1890.
Hamlin, *Amer. Jour. Psychol.*, **8**, 1896.
Moyer, *Amer. Jour. Psychol.*, **8**, 1896.
Birch, *Amer. Jour. Psychol.*, **9**, 1897.
Darlington and Talbot, *Amer. Jour. Psychol.*, **9**, 1897.
Binet and Henri, *L'année Psychol.*, **3**, 1897.
Toulouse et Vaschide, *Comp. rend. de soc. de biol.*, **11**, 1899.
Stevens, "A Plethysmographic Study of Att.," *Amer. Jour. Psy.*, **16**, 1905.
Geissler, *Amer. Jour. Psy.*, 473–529, 1909.
Breitwieser, *op. cit.*, pp. 17, 30, 1911.

CHAPTER III

EXPERIMENTAL PROCEDURE

Two rooms were used for the experiment. The subjects sat in a dark room, in which walls, ceiling, floor, tables and apparatus were painted black. The room was 24 by 14 by 14 feet, and was lighted by a 12 c.p. carbon filament light at a distance of 10 ft. at the left and back of the subject. This bulb was enclosed and the light came from the end, only, through two sheets of white tissue paper. With this amount of light it was just possible for the subject to see the point at which the light stimulus would appear. This in fact was the only purpose of the light. When the touch stimulus was given the room was well lighted from overhead by a 100-wt. tungsten light. This was necessary as the subject himself adjusted the touch key. However, as soon as the key was adjusted, the subject placed his hand on the reaction key, then closed his eyes until after the reaction was made.[1]

I. Production of the Stimuli to which Reaction was Made

Three forms of stimuli were used, viz., light, sound and touch. Each of these was presented alone, and also with sound, light and touch distractions.

A regular order of presentation was followed both in the training and in the control experiments. If the order had been changed from day to day certain constant errors might have been eliminated; but in this experiment better control was obtained by a regular order of precedure (see p. 33).

1. *Light Stimulus.*—The light appeared on a dark gray background through a circular opening 5 mm. in diameter. The background or screen was 24 by 30 inches, and was placed approximately 10 inches from the eyes of the subject. As an adjustable head rest was used, and as the screen was also adjustable in height, the stimulus was constant in position for all persons.

The light stimulus was produced by a flash of a Geissler tube in

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[1] The room was ventilated with an electric fan when the experiment was not in progress. The temperature was uniform throughout the year. This constant factor tends to eliminate the variable error which might be attributed to temperature.

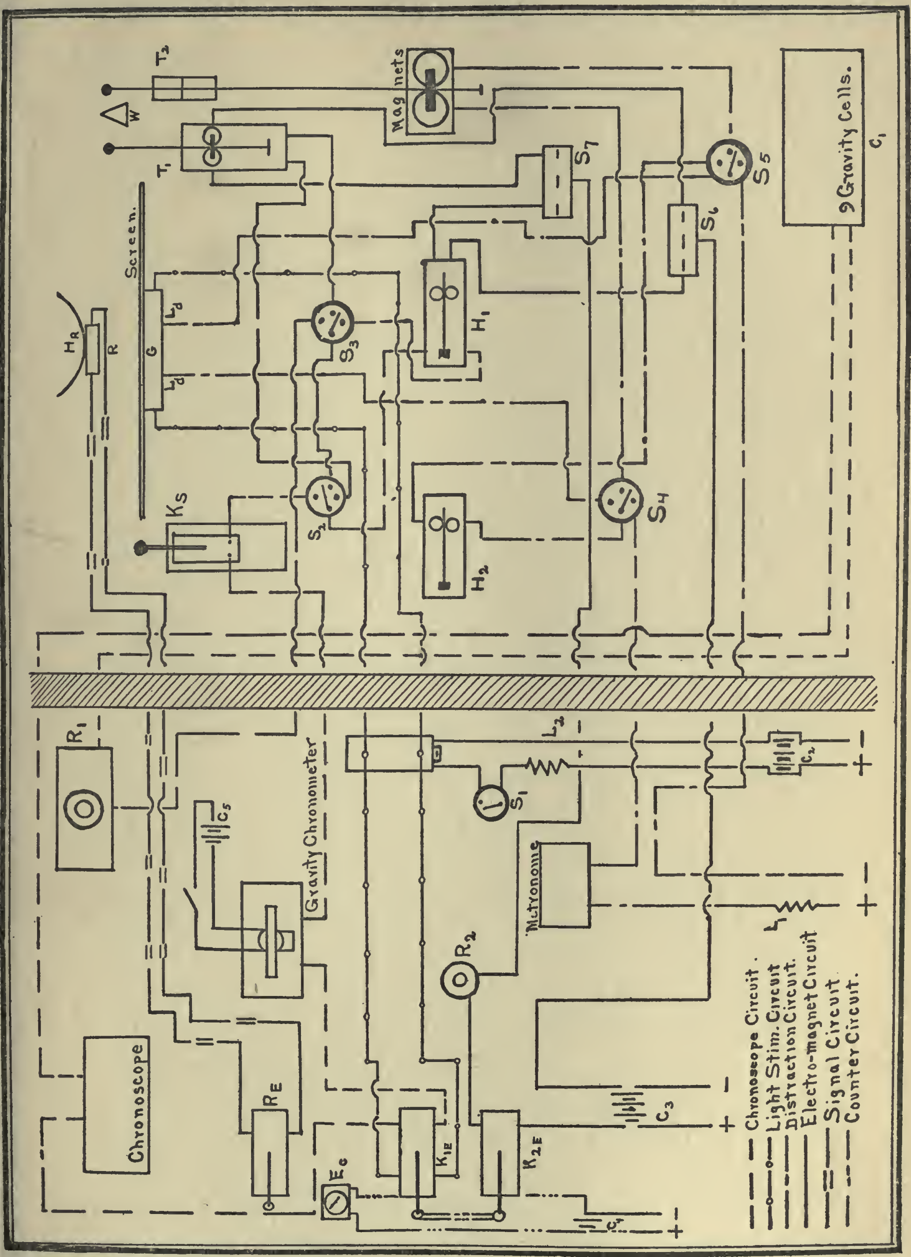
T_2
W
T_1
Magnets
Screen.
H_R
R
G
L_d
L_d
S_3
S_7
S_5
S_6
H_1
S_4
S_2
K_S
H_2
9 Gravity Cells.
C_1
R_1
C_5
Gravity Chronometer
L_2
S_1
C_2
Metronome
R_2
L_1
Chronoscope
R_E
K_{1E}
K_{2E}
E_0
C_3
C_4
Chronoscope Circuit.
Light Stim. Circuit.
Distraction Circuit.
Electro-magnet Circuit
Signal Circuit
Counter Circuit.

FIG. 1

circuit with the secondary circuit of an induction coil.[2] The coil was rated at one half inch spark of about 100 flashes per second, though a test showed the spark to be somewhat stronger than this with the current used. The intensity of the current through the primary coil was .8 ampere. Martin has stated that primary currents not exceeding 0.8 to 1 ampere intensity give sparks of virtually equal duration, other factors remaining equal.[3]

The coil was connected with four dry cells (C^2) in parallel. These in turn were connected in parallel with the university dynamo current (116 V. d. c.), with one 16 c.p. carbon filament lamp (L_1) in parallel for resistance.

The flash through the Geissler tube, and the chronoscope, were controlled by a double contact key (K_{1E}) devised for this purpose. The current flowed continuously through the primary coil of the inductorium, while an experiment was in progress *i. e.*, while a set of 10 reactions was made. This required about thirty or forty seconds. The secondary circuit was short-circuited through the coil by the upper contact on the key (K_{1E}) due to the greater resistance of the tube. To give the stimulus, the upper contact was broken. This directed all the current to the tube which overcame its resistance and made the spark in the tube, while a contact made by the same downward pressure of the key started the chronoscope. These two acts, the breaking and the making of contacts, occurred simultaneously, with little chance for variation.

This arrangement reduced the variable error due to irregularity in starting the induction coil, etc., which has entered into many experiments, and practically eliminated the constant error of the flash. No change was noted from day to day in the intensity[4] of the light. But even a change of 50 per cent. in the light intensity will make a difference of only a few sigma in the reaction-time.[5] As the light of a Geissler tube is different from the light we usually see, and this in itself might influence the reaction time, yellow sheets of gelatine were used to make the light white. This eliminated the strangeness and did not greatly lessen the intensity. The light by

[2] Cattell, *Phil. Studien*, 1886, **3**, 458–9. Berger, *Phil. Studien*, 1886, 40–41. Patrizi, "La Graphique psychométrique de l'attention," *Archives italiennes de Biologie*, **22**, pp. 189–196. Salow, *Psychol. Studien*, 1913, **8**, 6, 508. Swift, *Amer. Jour. Psychol.*, 1892, **5**, 1–19. Seashore, *Iowa University Studies in Psychol.*, 1899, **2**, 66.

[3] Martin, *Amer. Jour. Physiol.*, 1910, **26**, 183–188.

[4] Berger, *Phil. Stud.*, 1886, **3**, 64. Wundt, "Phys. Psychol.," 351, 1887. Slattery, "*Stud. from Yale Psychol. Lab.*," 1892, p. **71**. Cattell, *op. cit.*, p. 396, 1893. Froeberg, Archives of Psychol., 1907, No. 8, p. 33. Todd, *op. cit.*, p. 7.

[5] Froeberg, *op. cit.*

photometric measurement was 0.8 c.p. The distracting light was 2 c.p.[6]

The latency of any tube is very small as the pressure is only about 2 mm. Dodge by his photographic method found the latency to be .01 second. Dunlap noted it as somewhat less. By the arrangement used here the tube seemed to reach its full intensity instantaneously. A photographic plate falling before the tube as it was flashed revealed no increasing intensity in the light. Cattell in some of his earlier experiments noticed that the tube he used grew to its full intensity slowly enough to be observed. But Helmholtz[7] showed, as remarked by Martin,[8] that the induced current attains its maximum intensity at the instant the spark ceases to pass across the broken primary circuit.

2. *Sound Stimulus.*—The sound stimulus was produced by a sound hammer (H_1) of standard form[9] placed on a solid table, directly in front of the subject at a distance of about 3 feet. No deduction has been made in the reaction times for this distance, which would decrease the indicated time by 3 σ, since the results are used only for comparative purposes.

The sound hammer was adjusted till no noise was perceptible from the contact made by the electro-magnets.[10] The anvil was covered with a thin, smooth sheet of lead foil to insure perfect contact. The hammer was adjusted to fall 2 mm. A felt pad above the hammer prevented any noise from the rebound.

The magnets of the sound hammer were operated by four dry cells (C_3), wired in a manner similar to the cells operating the induction coil. A current of 4 volts and 0.3 ampere was maintained by means of a rheostat (R_2) in series.

The sound was tested from time to time by means of a falling steel ball, weighing 8 grams. Judged by two persons, the sound was similar to the ball falling on the same anvil from a height of 10 mm.[11]

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[6] Some trouble was experienced at first due to the noise made by the current to the Geissler tube but this was eliminated by using larger and better-covered wire with perfect connections and free from contact with other wires or apparatus.

[7] Poggendorf's *Annalen der Physik u. Chemie*, 1851, **83**, 505 ff.

[8] *Amer. Jour. Physiol.*, 1910, **26**, 181.

[9] Myers, "Experimental Psychol., II., p. 42, 1911. Todd, *op. cit.*, p. 6.

[10] The hammers are so constructed that the hammer strikes the anvil before the electro-magnets make the contract. The hammer bar is bent down by the pull of the magnets and when the current is broken springs up with a metallic sound not unlike "ping." This was corrected by making the hammer strike the anvil simultaneously with the contact of the magnets or even after the magnet contact was made.

[11] The sound of the hammer, however, was reported by some subjects during the course of the experiment to vary in intensity. This change was obviously

3. *Touch Stimulus.*—The touch stimulus was produced by the touch key (T_1) previously used and described by Cattell and Dolley.[12] The hammer weighed 15 grams and fell from a perpendicular distance of 25 mm. The surface giving the blow was 3 mm. in diameter and made of brass.

The area stimulated was the back of the inner side of the index finger of the left hand midway between the first and second joints.

The procedure in case of touch was slightly different from that of sound and light. The type of touch key used made it necessary for the subject to reset the key after each stimulus. This he did with his right hand, then replaced the hand on the reacting key, the operation requiring from 4 to 6 seconds. The room was well lighted for this part of the experiment, in order to permit the subject (S) to locate immediately the touch key and the reacting key. As soon as he replaced his hand upon the reacting key, he closed his eyes and awaited the stimulus.[13] This procedure probably tended to make the reactions of the sensory type, though results or introspection failed to prove of which type the reactions were, if wholly of either type. It seems possible that the procedure did prevent any tendency to anticipate the stimulus or to use the distraction as an aid when the tendency appeared.

The same current which was used for the sound hammer was used for the magnets of the touch key by means of a two-point switch.

The period of actual stimulation was only a few sigma, and was subject to no variations that could affect the reaction time.[14]

II. REAGENT'S KEY

The reagent's key was of the regulation telegraph type (K_R); 100 grams pressure was sufficient to make a contact. The range of movement at the point of contact was 2 mm. All the subjects found this arrangement agreeable. The key was mounted on a weighted block, and was moved to any part of the table to suit the subject's convenience. The subject reacted by releasing the key in any convenient manner; all subjects actually reacted by a finger and wrist movement.

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a subjective change, but such changes may account for some of the variability in the time of reacting.

[12] *Op. cit.* Illustrated, p. 413, see Table XII., p. 414; also p. 409. Froeberg, *op. cit.*, quotes part of the same table, p. 9.

[13] Killen, B., "The Effects of Closing the Eyes upon the Fluctuations of Attention," *Amer. Jour.* 1904 *Psychol.*, 15, 512.

[14] See Froeberg, *op. cit.*, and Wells, G. R., "The Influence of Stimulus Duration on Reaction-time," *Psychol. Rev. Mon.*, 1913, 15, No. 5, pp. 59, 60.

Cattell found the wrist movement to give the fastest reaction with one subject and the finger movement with another subject.[15] Bryan found the elbow to be the most rapid joint for the tapping test.[16]

III. The Distracting Stimuli

Three forms of distraction were used, light, sound, and touch. The distraction apparatus was operated mechanically by the make and break of the mercury contact of an electrical metronome. The current was derived from the University dynamo current (116 V.) with lamp resistance (L_2). The metronome made 36 beats in 30 seconds, and a contact was made every two beats as only one mercury contact was used.

1. *The Light Distraction* was produced by three tungsten lamps (25 w.) (L_d) which, as well as the sound hammer (H_2) and touch instrument (T_2), to be mentioned, were wired in circuit with the metronome, the current to the different pieces being controlled by the necessary three-points witches (S_2 and S_3). The lamps were enclosed in a box behind the background screen. Two cm. above the aperture through which the light from the Geissler tube was flashed was another aperture of the same size, *i. e.*, 5 mm. in diameter, covered with one sheet of white translucent paper. Through this circular opening the light from the three lamps was flashed as the metronome made contact.[17]

2. *Sound Distraction.*—A second sound hammer (H_2) was used for this distraction. Both the quality and intensity of the noise were different from the sound stimulus. The hammer was adjusted to fall 5 mm., and its noise was equal in intensity to that of a steel ball weighing 8 grams falling 45 mm. The hammer was placed 2 feet to the right of the first hammer and 3 feet, 10 inches in front and to the right of the subject.

3. *Touch Distraction.*—Touch distraction was produced by a falling weight, supported by a series of levers to give it proper range. The weight was pulled up 2 cm. by the contact of two large electromagnets (T_2) with one arm of a lever. The breaking of the circuit by the electric metronome allowed the weight to drop.[18] This

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[15] *Op. cit.*, p. 410, Table.

[16] "Voluntary Motor Ability," *Amer. Jour. Psychol.*, 1892, 5, 149.

[17] The lamps for resistance (L_2) were in the room of the experimenter and flashed out at each contact made by the metronome. This gave the experimenter assurance that the distraction was always working properly.

[18] Considerable difficulty was encountered with the mercury contact, especially in connection with the touch apparatus, due to the volatilization the sound of which seemed to be transmitted to the electromagnets in the S's room and caused a slight sound. Much of this was overcome by using a soft copper

weight weighed 70 grams and fell 2 cm. Due to the hindering action of levers the blow exerted was equal only to a weight of 20 grams falling without impact.

The contact was made on the back and right side of the second finger of the left hand between the first and second joints. The area of stimulation was 5 mm. in diameter. The contact point of the weight was 2 mm. square and made of wood fiber. The first and second fingers of the left hand were placed astride of a triangular block of wood (*w*) fastened to the table. This kept the hand stationary.

IV. Instructions to the Subject

In general: "When the signal is given, place the fingers on the key as if to telegraph and press the key down. When the stimulus appears, release the key as quickly as possible."

Reactions to light: "When a light appears within the small white circle release the key as quickly as possible."

Reactions to light with light distraction: "A light will appear within the small white circle, and another light, slightly different in intensity, will appear in the opening directly above the white circle. React as before, *i. e.*, only when the light within the white circle appears. Give no special attention to the light above. The two will never appear simultaneously."

Reactions to light with sound distraction: "React to the light only. Give no attention to the sound" (position indicated).

Reactions to light with touch distraction: "A weight will touch you on the second finger. React as before to the light stimulus. Give no attention to the touch."

Reactions to sound: "When the sound is heard (indicated) react as quickly as possible."

Reactions to sound with sound distraction: "React to the sound as before; give no special attention to the extra sound."

Reactions to sound with touch distraction: "The weight will touch you on the finger as before. Keep the fingers in the same position. React with the right hand as before but not until you hear the sound."

needle, by removing the waste occasionally from the mercury, and by covering the mercury with melted paraffin. This hardened and prevented oxidation though it had to be renewed quite often. Near the close of the experiment Prof. Dodge called my attention to a mercury key devised and used by E. G. Martin (*Amer. Jour. Physiol.*, 1910, **16**, 183, 188) which could have been used successfully in this experiment. The key is devised to break the circuit by cutting the mercury. As the point of contact is beneath the surface no volatilization occurs. Another arrangement of a slightly different principle is described by Lombard (*Amer. Jour. Physiol.*, 1902, **8**, 20).

Reactions to touch: "When the weight hits you on the first finger of the left hand, react with your right hand."

Reactions to touch with touch distraction: "A weight will touch you on the left hand as mentioned before, when you reacted to light or to sound. Another will touch you on the first finger as previously. React to this last stimulus, but give no special attention to the other."

In general: "At the close of the set, a signal to rest will be given. Release the key and rest till the ready signal comes again."

At the close of the experiment, the subject was asked: "Did the other stimuli distract you? Which ones distract you most? How?"

"State your physical condition as excellent, fair, or poor."

"Give any remarks and introspections you may wish to give."

V. Method of Recording

The reaction times were recorded with a Hipp chronoscope, of the older type, the one improved and used by Cattell and Dolley.[19]

The chronoscope was controlled by a small gravity chronometer of the fall-screen type.[20] This had been previously tested with the large gravity chronometer figured and described by Cattell and Dolley.[21] The chronometer was adjusted for a standard interval of $100\,\sigma$.[22] Before each experiment 10 or more control readings were made and the chronoscope adjusted by increasing or decreasing the current, by the aid of a rheostat (Rh_1), as was necessary to secure a mean variation of less than $1\,\sigma$ per $100\,\sigma$.[23] The average deviation for any series of readings never exceeded $0.7\,\sigma$.

The current for the chronoscope was obtained from a battery of 9 gravity cells (C_1) kept fairly constant at 7 volts and 0.1 ampere.[24]

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[24] Todd, *op. cit.*, pp. 8, 9.

[19] Berger, *Phil. Studien*, 1886, **3**, 93. Cattell & Dolley, *op. cit.*, pp. 395, 396; also, note 1, p. 397, 1893. Külpe and Kirschmann, *Phil. Studien*, 1893, **8**, 153 f. Müller and Pilzecker, *Zeit. f. Psychol.* Ergänzungs bd. I., 292 f., 1900. Titchener, "Exper. Psychol.," Inst. Man'l, Quantitative, pp. 325, 327, 335, 1905. Edgell and Symes, *Brit. Jour. of Psychol.*, 1906, **2**, 85, 86.

[20] The wheel contact in this chronometer is identical, though smaller, with that of the larger instrument. See Cattell and Dolley, *op. cit.*, Fig. 4, 399.

[21] *Op. cit.*, p. 397, 1893. Cattell, *Phil. Studien*, 1894, **9**, 397. Titchener, "Textbook of Exp. Psychol.," Stud. Man'l, p. 152, 1905. Ins. Man'l (fig. —), p. 344, note 1, 343. Dunlap, *Brit. Jour. Psychol.*, 1911, **4**, 55. Myers, "Exp. Psychol.," II., 43, 50, 1911. Todd, *op. cit.*, p. 8, 1912.

[22] Titchener, *op. cit.*, p. 329.

[23] Cattell and Dolley, *op. cit.*, p. 406. Myers, *op. cit.*, II., p. 49, 1911.

VI. DISTRIBUTION OF APPARATUS

The head rest (H_R), the large screen in which the light stimuli appeared, the two sound hammers (H_1 and H_2) the touch key (T_1), and the accompanying apparatus for touch distraction (T_2), the reagent's key (K_R), and six switches (S_1, S_2, S_3, S_4, S_5, S_6) were on the table before which the subject sat, in the dark room.[25] The chronoscope, the chronometer, rheostats (R_1 and R_2), induction coil, metronome, lamp resistances (L_1 and L_2), electric counter, and two keys (K_{1E} and K_{2E}) were placed in an adjoining, almost sound-proof room, in which the experimenter sat.

The preparatory signal was given from E's table with an electric key (R_S). The gong was removed from a small electric bell and a small plate of sheet metal substituted. This was covered with a sheet of rubber and the clapper adjusted for a very small amplitude. The arrangement thus devised was placed on the head-rest (S_R) just below the chin of the subject. The sound was very faint and dull, and very different from that of the sound of the hammer. Two taps were used as a preparatory signal, and four taps indicated that the 10 reactions were completed. The subject signalled to the experimenter (E) during the course of the experiment, if necessary, by removing his hand from the key, and thus starting the chronoscope.

VII. PROCEDURE

After sufficient time for adjustment was allowed, the preparatory signal (2 taps) was given, then 3 seconds later the first stimulus was given, the chronoscope was then started and in approximately 3 seconds the second stimulus was given and so on, till 11 were given.[26] The concluding signal was then given (4 taps), the chronoscope stopped, the reading for the total of the 10 reactions made and recorded, the chronoscope adjusted and the second set of ten reactions was taken in like manner, except that the first reaction was now recorded. This was repeated five times when the simple reactions were made, but ten times when the distracting stimulus was added. About 10 seconds elasped between each set of reactions. At the end of each series of 100 reactions a rest period of at least 5 minutes was given. In most cases the 150 reactions concluded the experiment for that day.[27]

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[25] The room in which the S sat was not entirely sound proof. It did not adjoin the street, had no windows, but two doors. Only occasionally did any noise occur outside the room which may have affected the S's reaction-time. These were always noted in the introspections. When noise did occur the experiment was discontinued till condition changed.

[26] This method of taking 10 reactions before reading the chronoscope permits a great number of reactions to be made in a comparatively short time, and with ease. It has the disadvantage of not taking account of the variability of the separate reactions. This is hidden in the average. It is possible to watch the chronoscope and even make note of irregular reactions, as they occur, but seldom was this last done in this experiment.

VIII. The Relation of the Stimulus to the Distraction

When a distraction was applied, it recurred at regular intervals of $1\frac{2}{3}$ sec. The stimulus to reaction was never given at the same instant as the distraction, but either $\frac{1}{2}$ sec. from the beginning of the interval, in the middle of the interval, or about $\frac{1}{3}$ sec. before the end of the interval. This lack of uniformity prevented any rhythmical tendencies. Even one-fifth second variation is enough to prevent the subject from adopting definite rhythmical action. In most cases the subjects did not become aware of the relation of distraction and stimulus, as they were directed each day to react to the stimulus given, and to give no special attention to the distraction.

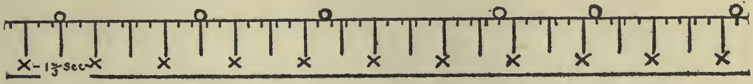

Fig. 2. The relation of the stimulus to which the subject reacted to the distraction stimulus. The O indicates the point in time at which the stimulus occurred to which reaction was made. The X indicates the point at which the distraction occurred. The long vertical lines indicate the ticks of the metronome. The smaller divisions represent thirds of a second.

In each case the distracting stimulus had more intensity or volume than the stimulus to which reaction was made. No attempt was made to make the difference between the distraction and the stimulus equal in all cases, as this would be very difficult.

No doubt it would have been possible, by the discrimination time method, to obtained equal subjective differences by selecting differences which were perceived in the same time.[28] However, the difference used never appeared excessive to the subject, nor so great as to place the distraction completely in the foreground to the detriment of the main stimulus. The attempt was made to have just enough difference to prevent confusion, or reaction to the wrong stimulus due to the inability to distinguish between the two. All the subjects were able to distinguish the two stimuli even from the very beginning.

[27] In the beginning only two sets (20 reactions) were taken with simple stimuli, but it was found that this was not enough to allow S to get adjusted and reach his normal limit. It seemed that S made improvement till 30 or 40 reactions were made, and then became fairly uniform.

[28] Henmon, *op. cit.*, 9–11.

IX. SIMPLE REACTION WITH DISTRACTION AS OPPOSED TO ADAPTIVE REACTION

It may be well, at this point, in order to avoid some unnecessary confusion, and to meet one possible objection, to distinguish between simple reaction with distraction and adaptive reaction or reaction with choice, which at first may seem to be involved in this experiment.

Simple reaction involves but one stimulus, while adaptive, or reaction with choice must have at least two stimuli between which to choose. Both are presented to consciousness. One can not be neglected for the other, and no reaction (unless premature) can follow till both or all are compared, or one judged in the light of the others, no matter whether several movements or the single movement is used in reacting.

In adaptive reaction both discrimination and choice are involved. When one of two stimuli is presented, the subject must distinguish which has been presented, before any movement toward a reaction can be made. The choice of right or left hand, or of any particular finger must be made and then the proper reaction given to the stimulus. This process involves the higher centers and does not become reflex quickly, as each stimulus demands continually the process of distinction and selection.

The adaptive reaction gives opportunity for false reactions which occur more or less frequently. On the contrary, false reactions need never occur when reacting under distracting conditions. The subjects reported that there was seldom, if ever, any tendency to make false reactions, and few occurred.

X. PREMATURE REACTIONS

If the subject reacted before the stimulus appeared, the reaction would be a false reaction. These would not influence the recording apparatus. If the subject reacted just as the experimenter gave the stimulus, the reaction would be a synchronous reaction. As the subject makes the reaction at the time the experimenter gives the stimulus the recording instrument would fail to move, or show but a very few *sigma* at the most.

As a rule, in premature reacting the subject reacts a few *sigma* after the stimulus has been given, although he has not yet perceived the stimulus. It is the reactions of this type which vitiate results as they so nearly approach the subject's normal reaction time as to leave the experimenter in doubt about them. Thus several reactions 5 to 10 σ too short may occur but only one or two reactions which the experimenter recognizes with certainity as premature.

Let us suppose that the normal reaction of a subject is about 116 σ to a sound stimulus. After a short practise period he makes this reaction quite frequently. When an occasional reaction of less than 100 σ occurs no injustice is done the subject if this reaction is designated as premature. But suppose, while the normal reaction to a sound stimulus is 116 σ, that a few reactions 105 σ in length occur. It is not impossible for the subject to make such reactions, but they are more probably premature though it is impossible to tell in any system of registering the time whether they are true or premature reactions. Thus there may be several reactions 5 σ or 10 σ less than the normal reactions used in a series but only one or two reactions which the experimenter recognizes with certainty as premature. Although these last premature reactions may be excluded from the list, the general average of the series will still be too small due to the other short reactions, or the strong tendency to make premature reactions.[29]

The best method to follow in the above case is to vary slightly the time between the "Ready!" signal and the presentation of the stimulus.

Premature reactions rarely occurred in this experiment, and only then when the interval between the signal and the stimulus was the longest.

The introspections of the subjects are valuable in determining these premature reactions, but only when the reaction is very short. The subject rarely knows that he has made a premature reaction, if the reaction is about equal to his normal time of reacting.

While a few short reactions were made by two subjects, *E* and *F*, the attempt was made to avoid these by emphasizing again and again the directions, and if necessary discontinuing the work till a later period.

XI. The Subjects

All the persons who served as subjects were interested in psychology, and were connected with the university either as student or instructor while they were serving as subjects. Two of the persons in the practice group were familiar with reaction time experiments and apparatus in a general way (Subjects *C* and *E*). Subject *B* was an experienced subject having served both as subject and experimenter in similar work. Of the control group only three persons had any general knowledge of reaction time work (Subjects *W*, *Z*, *X*).

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[29] For a time one subject tried to make the noise of the sound hammer and the slight "ting" of his key synchronous as a musician does his time with the metronome. Another applied the same to touch and attempted to react just as the key touched his hand. All will admit that such attitudes tend to produce premature reactions.

False reactions could not be recorded as the chronoscope would not operate if the S broke the circuit previous to the making of the circuit by the experimenter.

The data obtained from the control group afforded an adequate check on the data of the practise group. Without such data it would be unsafe to attribute the decrease in the reaction time to the practise received in the training period. The time which intervened between the preliminary and final control test might account for the decrease. Such data, of course, are absolutely necessary in determining the amount of transfer which occurs in a practise group. The data of the control group in both the preliminary and final tests are found in Tables XXVI.–XXXIII.

XII. The Nature of the Training

The subjects in the practise group may be divided into three groups on the basis of the character of the training. In the case of all the subjects there was a period of training in reacting to a certain stimulus with a definite distraction present which was much longer than the period of training in reacting to the other stimuli.

1. *Subjects A and B.*—Subjects *A* and *B* reacted to a light stimulus throughout the experiments. The first distraction introduced was light. The main part of the training was in reacting to a light stimulus with a light as a distraction. After this training the light distraction was replaced by a sound distraction, and this later replaced by a touch distraction. Thus *A* and *B* reacted to a light stimulus under the influence of a light distraction, then to light when accompanied by a sound distraction, then to light with a touch distraction present.

2. *Subjects C and D.*—Subjects *C* and *D* reacted to a sound stimulus with sound as a distraction. In this they received their main training. This was followed by reactions to sound with light as a distraction, and then by reactions to light with touch as a distraction.

3. *Subjects E and F.*—The training of *E* and *F* was slightly different from the training of *C* and *D* in one respect. In order to note the effect of distraction upon a practised performance or a performance near the limit of practise, *E* and *F* were trained in reacting to sound without any distraction present. At the close of this period of training they reacted to the same sound stimulus with a sound distraction present. The sound distraction was then replaced by a light distraction, and this in turn was replaced by a touch distraction. With the exception of the first special training in reacting to sound, the training of *C* and *D*, and *E* and *F* was identical.

By introducing this period of training in simple reaction it is possible to so acquaint the subject with all the extrinsic influences which enter into the experiment that they will have no influence on his reaction-time. Then, when the distraction is introduced, what change really occurs will not be distorted by the presence of these other influences.

XIII. Attitudes

In any experiment the attitude of the subject toward the act or process which he is to execute has an important influence on the result. This is especially true in the present experiment. The subjects were making a long practise series of reaction-times, as well as developing a power to resist the influence of distractions. The work was routine, and was continued over a long period of time. The subjects had but a very general knowledge of the results obtained from day to day. The various conditions of health, fatigue, diurnal changes, etc., tended to cause changes in the efficiency of individuals which in turn influenced their attitude.[30]

There is always the possibility that the subject may ignore from time to time the directions given for guidance. This may be done consciously or unconsciously, but it usually occurs when the subjects attempt to change their methods of action. At certain times it seemed that one or two of the subjects in this experiment attempted to use the distraction as an aid in reacting; the futility of this procedure manifested itself immediately, but even with the best trained subjects some range must be allowed for chance reactions. On the whole, however, the subjects were able to follow the instructions implicitly and thus to maintain a uniform attitude throughout the experiments.

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[30] "The most important fact about the curve of efficiency of a function under two hours or less of continuous maximal exercises is that it is, when freed from daily eccentricities, so near a straight line and so near a horizontal line. The work grows much less satisfying or much more unbearable, but not much less effective. The commonest instinctive response to the intolerability of mental work is to stop it altogether. When, as under the conditions of the experiments, this response is not allowed, habit leads us to continue work at our standard of speed and accuracy. Such falling off as does occur is, in the writer's opinion, due to an unconscious reduction of the intolerability by intermitting the work or some parts of it."—Thorndike, "Educational Psychol.," III., 69.

CHAPTER V

THE EFFECT OF DISTRACTION UPON REACTION-TIME IN THE PRESENT STUDY

I. As a Preliminary Survey, the Following Problems May be Proposed for Solution

1. The effect of a light distraction, a sound distraction, or a touch distraction on reaction-time.
    - (*A*) With trained subjects.
    - (*B*) With untrained subjects.
    - (*C*) With subjects trained in reacting to the stimulus before distraction was introduced.
    - (*D*) Within the daily work curve.
2. The effect of practise on distraction.
    - (*A*) Is the distraction effect eliminated by practise?
    - (*B*) Does the distraction have greater effect on a practised or unpractised performance?
    - (*C*) Is the time for daily adaptation to the distraction reduced?
    - (*D*) To what degree is variability reduced?
3. The "warming up" period in the daily work.
4. The most effective distraction.
5. Some extrinsic influences.

Figures 3 to 8 give a graphic representation of Tables I. to XVII. The ordinates represent reaction time in sigma, while the abscissæ represent periods or sittings in the experiment. Each curve is divided into three parts as three different distractions were used. The solid line represents the reaction time with distraction; the broken line the time without distraction which served as the daily control test. The star with the arrow attached indicates the performance of the subject in the preliminary test before practise began. What gain occurred was made without further practise in the same performance, but on account of practise in other performances.

In the curve for *C* there is given in addition to the regular curves the smoothed curve for reaction-time both with and without distraction. In addition to the curve for *D* there is given also a graphic representation of the P.E. for this same curve. It may be noted that there are only two points at which the two areas overlap or meet.

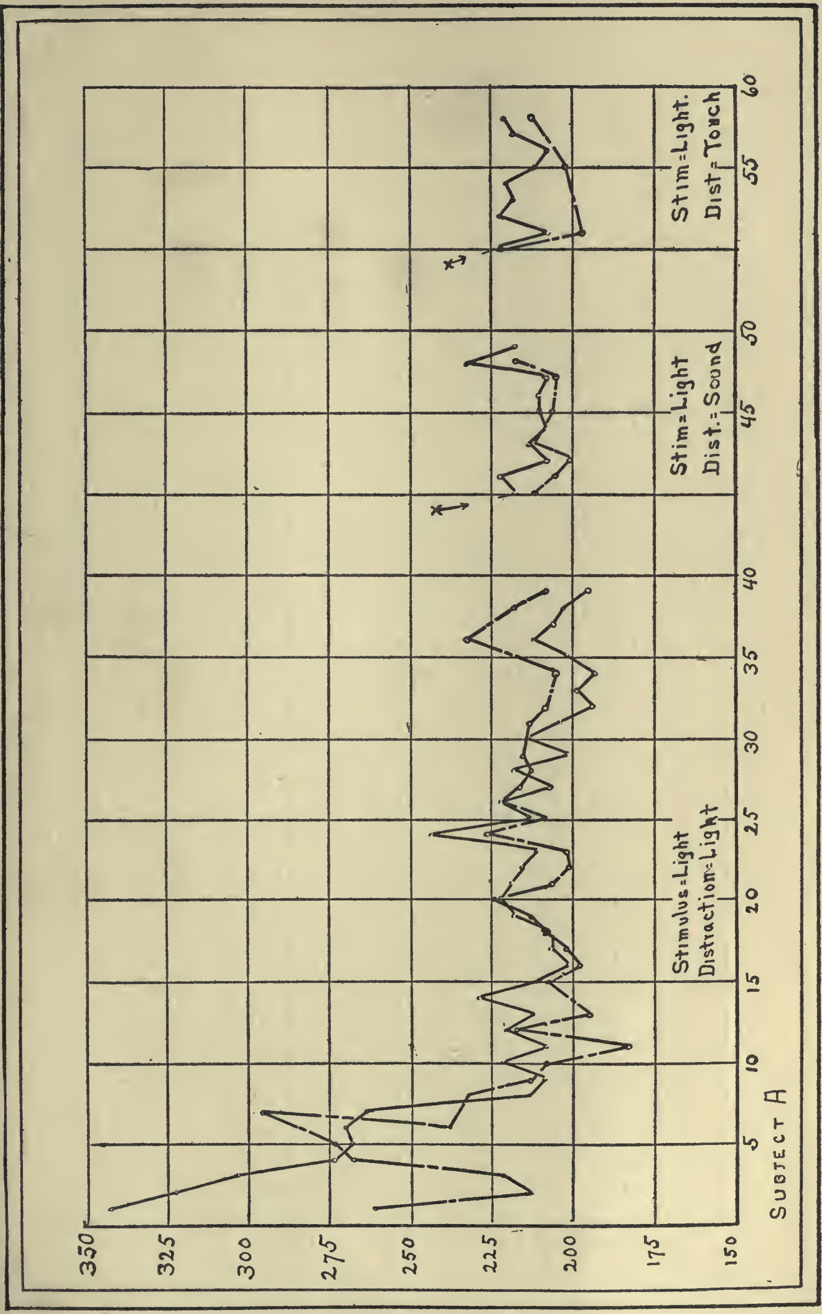

Fig. 3. Graphic representation of Tables I, III, and V.

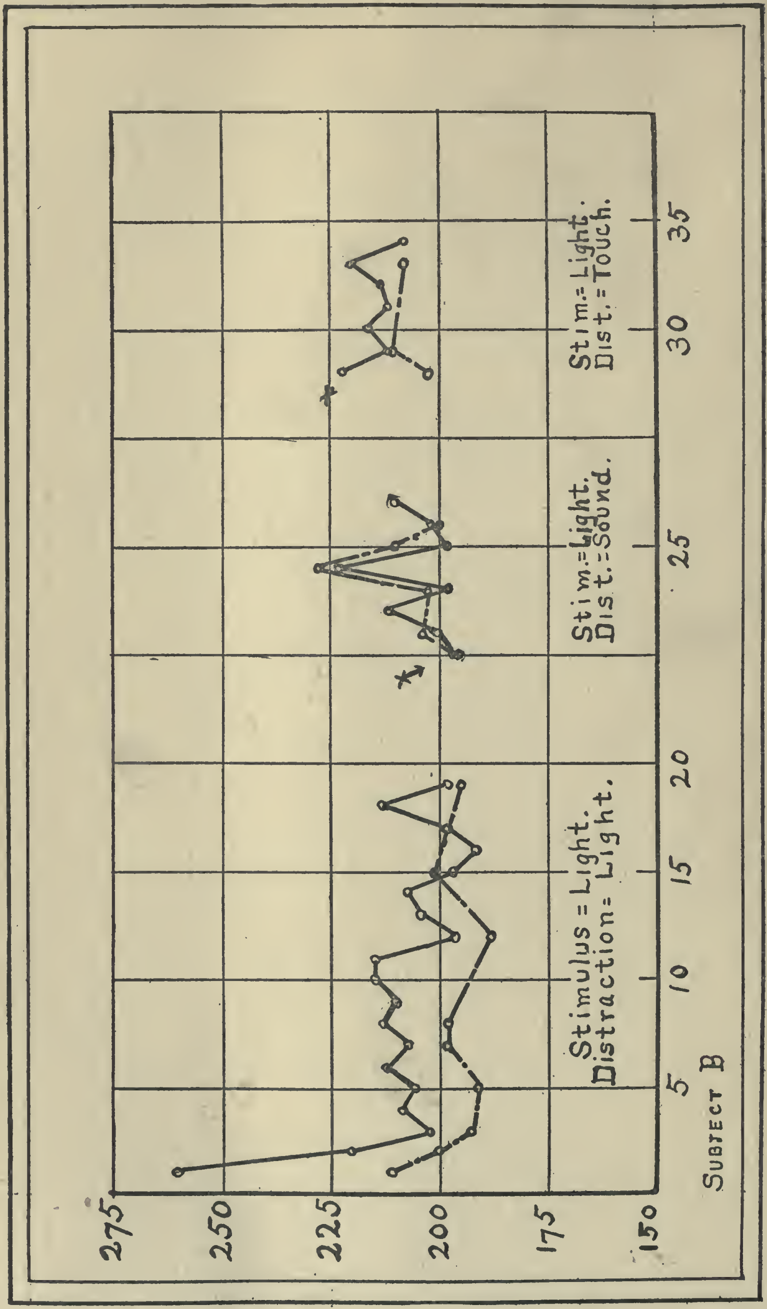

Fig. 4. Graphic representation of Tables II, IV, and VI.

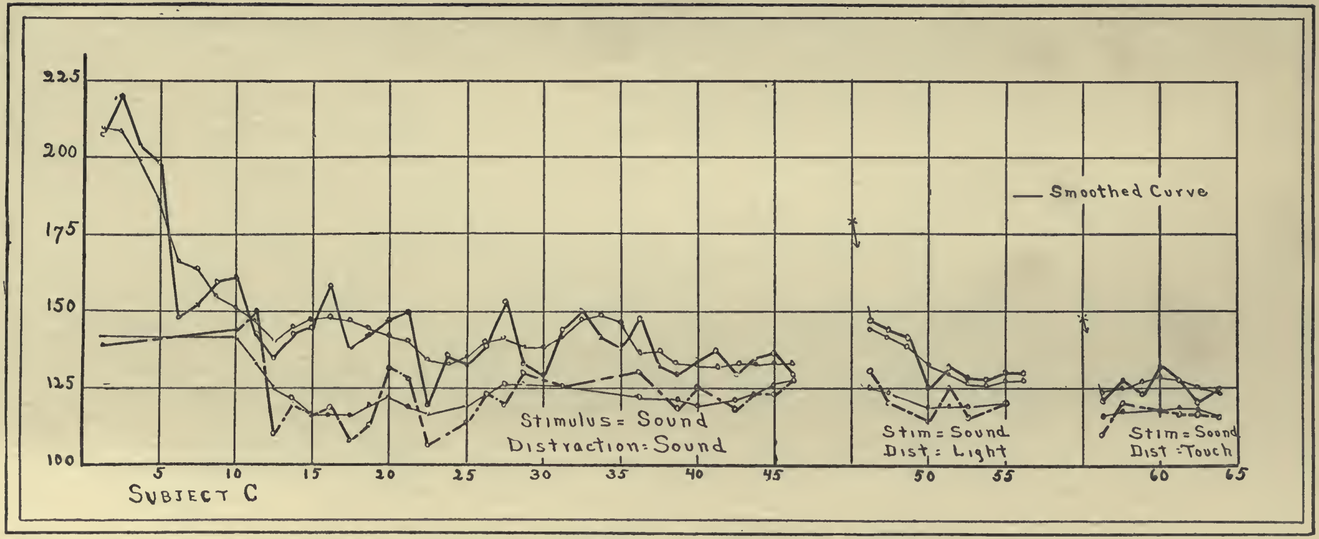

Fig. 5. Graphic representation of Tables VII, VIII, and IX.

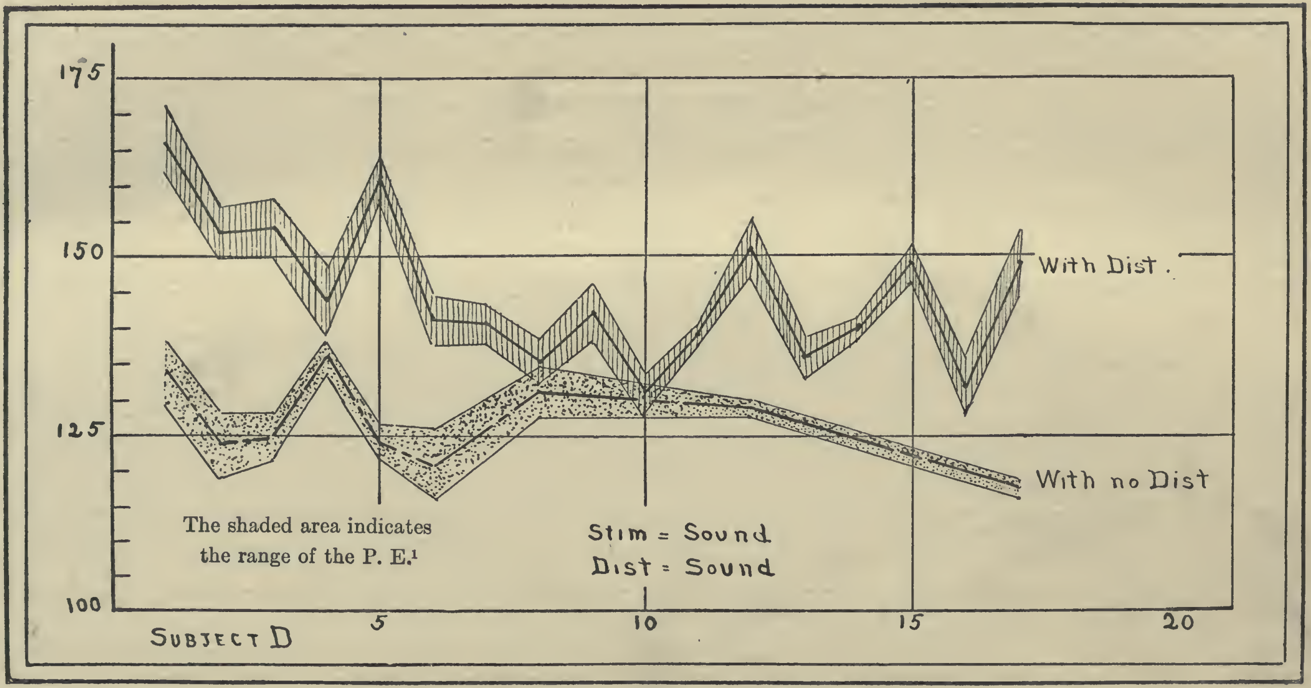

FIG. 6. Graphic representation of Table X.

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[1] For meaning of P. E. see page 35.

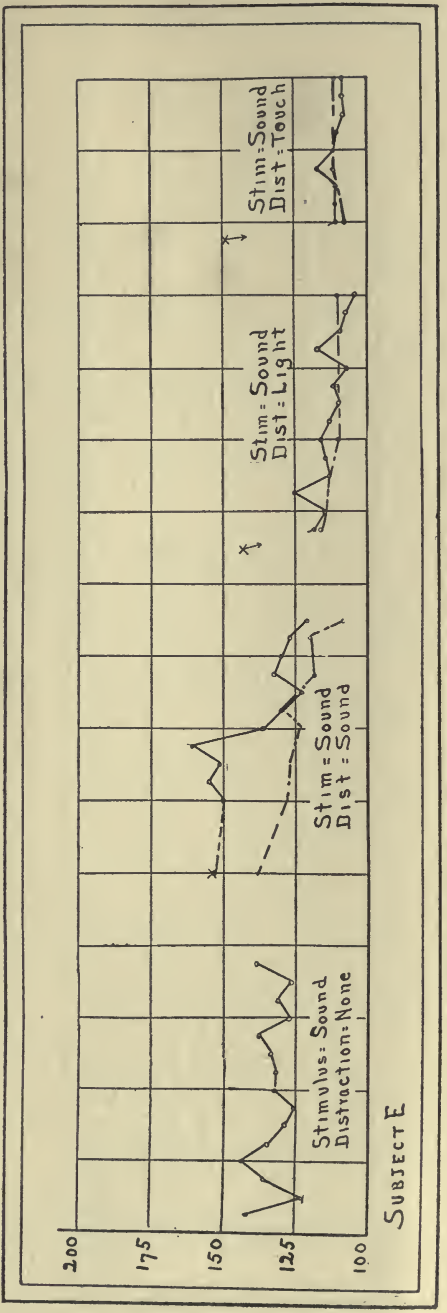

FIG. 7. Graphic representation of Tables XI_A, XII, XIV, and XVI.

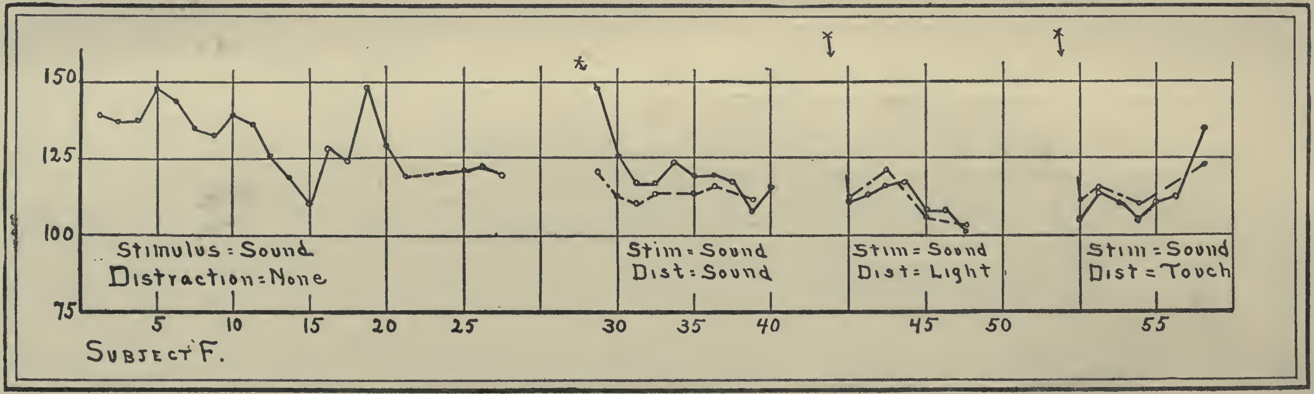

FIG. 8. Graphic representation of Tables XI$_B$, XIII, XV, and XVII.

II. Order of Procedure

The subjects were given training in the following order:

Practise Group

1. Subjects *A* and *B*
   - (*A*) Preliminary control test (See p. 34.)
   - (*B*) First practise series

Stimulus	Distraction
Light	Light

   - (*C*) Second practise series

Stimulus.	Distraction
Light	Sound

   - (*D*) Third practise series

Stimulus	Distraction
Light	Touch

   - (*E*) Final control test

2. Subjects *C* and *D*
   - (*A*) Preliminary control test
   - (*B*) First practise series

Stimulus	Distraction
Sound	Sound

   - (*C*) Second practise series

Stimulus	Distraction
Sound	Light

   - (*D*) Third practise series

Stimulus	Distraction
Sound	Touch

   - (*E*) Final control test

3. Subjects *E* and *F*
   - (*A*) Preliminary control test
   - (*B*) First practise series

Stimulus	Distraction
Sound	None

   - (*C*) Second practise series

Stimulus	Distraction
Sound	Sound

   - (*D*) Third practise series

Stimulus	Distraction
Sound	Light

   - (*E*) Fourth practise period

Stimulus	Distraction
Sound	Touch

   - (*F*) Final control test

In each of the practise series above the subjects first made 50 reactions to the stimulus, then 100 reactions to the same stimulus with the distraction, at each practise period. The preliminary control test and the final control test which were given to all of the subjects in both the control group and the practise group consisted of the following work:

Stimulus	*Distraction*	*No. of Reactions*
Light	None	50
"	Light	50
"	Sound	50
"	Touch	50
Sound	None	50
"	Sound	50
"	Light	50
"	Touch	50
Touch	None	50
"	Touch	50

III. COMPARISONS

For ease of comparison the tables of the present study are grouped together (see pages 72 to 106). The sequence is indicated under the topic, "Order of Procedure." While the work of each individual is indicated in a separate table the attempt has been made to keep the work of exactly the same nature together to allow easy comparison. Thus, the first comparison should be between the different subjects in the smaller groups, then any one subject with any other in the whole group. Thus *A* may be compared with *B*, *C* with *D*, then *E* with *F*, or *C* with *E*, or *F*, etc. *A* may then be compared with any other subject, etc.

IV. COMPOSITION OF THE TABLES

Each table is composed of two series of reactions each complete in itself. The first series gives the reaction time without distraction, or the simple reaction time, and serves as a daily control for the second series in which the influence of the distraction was present.

The first series is made up of 5 sets of 10 reactions each with the accompanying M.V., and P.E., excepting the cases noted on page 21. The second period is made up of 10 sets of 10 reactions each. The M.V. and P.E. are given for each of these averages of 10 sets. Thus each figure in the first series with no distraction represents the average of 50 reactions,[1] and of 100 reactions in the second series with distraction.

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[1] The exceptions have been stated early in the discussion. (See p. 21.)

The date indicated in the first column denotes the time when the two series of reactions in the second and fifth columns were made. With few exceptions only one series was made in one day, but occasionally more than one series was made with distraction present. In this case the date is followed by one series of numbers in the second column, and two series in the fifth column. The single series served as the control test for the two series with distraction.[2]

Under "*R*" is given the ratio of the series of reactions with distraction to the series without distraction. This indicates in a degree the relation of the two series from day to day. If the two series vary in about the same degree from day to day it may be noted in these ratios. If the ratio is greater than 1.00 the reaction time with distraction was greater than the simple reaction time. These ratios are grouped in groups of 5 when possible and the general average given in the last column. The general average of each series is given beneath its proper series.

V. Calculations

1. The mean variations given under M.V. in Tables I. to XVII. are the mean variations of the averages of the separate sets of 10 reactions from the day's average. Thus the variations of the averages of all the series is shown from day to day. This method takes no account of the variation of single reactions in a set. A comparison of the three possible methods has been made by Poffenberger.[3] He states that the variations within a series are about the same as those among the different series, while the variations of the individual reactions from the general average are about 50 per cent. higher than either.

2. *Probable Error of the Average.*—The probable error (P.E.) was calculated to the formula:

$$\text{P.E.} = \frac{.8453\ \text{M.V.}}{n}$$

3. *The Probable Error of a Difference.*—($\text{P.E.}_{\text{diff.}}$) was calculated according to the formula:

$$\text{P.E.}_{\text{diff.}\ A\text{–}B} = \sqrt{(\text{P.E.}\ \ )^2 + (\text{P.E.}_B)^2},$$

in which P.E._A is the probable error of the average of *A* by the preceding formula and P.E._B the same for *B*. Reference to page 50 will show P.E._A, as used, to be the probable error for the average gain in the final control test over the preliminary test for the practise group, and $P.E._B$ the same for the control group.

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[2] The experiments were made in 1913–14.

[3] "Reaction-time to Retinal Stimulation," Archives of Psychology, 21, No. 1, p. 46.

4. The Relative Variability of each subject in each class of reactions is shown at the bottom of each of the previous tables. The relative variability here means the average M.V./Av., where M.V. is the mean variation of the several sets of reactions taken in each period, and Av. is the general average of these sets. The figure given is the general average of these quotients for the entire series; it is the general average of a series of Pearson Coefficients of Variability.

VI. The Distraction Effect

To reiterate: the subjects were instructed to attend to the stimulus, react to it as quickly as possible, and give no special consideration to the distraction. This factor, no doubt, tends to lessen the difference between the simple reaction time and the reaction time with distraction.

After instructions were given, a few preliminary trials were made, in which the position in space where each stimulus and each distraction would occur was emphasized.

1. *Meaning of "Distraction Effect."*—By "effect" here is meant the difference in the time with distraction from the simple reaction time or time without the distraction.

Distraction effect is indicated both by the tables and graphically.

The tables of individual reactions represent only averages, that of pure reaction for 50, and with distraction for 100 reactions. These are indicated on the graph by a dotted line and a solid line respectively.

A general discussion is not applicable to the six, but some facts may be noted in the individual records.

2. *Discussion of Individual Records.*—(*a*) *Subjects A and B.*—These subjects began the experiment by reacting to light with light distraction. *A* was inexperienced, *B* was well trained, having served as subject and experimenter in other reaction experiments.[4]

Subject *A* at the beginning had a difference between the pure reaction time and the time with distraction of 81.9 σ, while at the close of 39 days of training with light distraction, the difference was 14.8 σ in favor of the distraction reaction. If the table of ratios is examined, it will be found that within this training series there were 18 cases where the distraction did not slow the reaction but even facilitated it. This is about one half of the cases. We might conclude, in the absence of further evidence, that while light acted as a distraction in the beginning, the subject gradually overcame this influence in the latter part of the series. But from an intimate knowledge of conditions and from the introspections of this subject, it is certain that these ratios do not represent the real effect of the distraction. In the beginning of the experiment twenty reactions were thought to be a sufficient number for the control on each day. But this was found to be too small a number, as the "warming up" required at least forty reactions before the minimum time of reaction was reached. This was very noticeable with *A*. He seemed to require considerable time to "get set" or warm up to the ways of the experiment.[5]

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[4] *B* is the same as subject *P* in: Todd, *op. cit.*, and Poffenberger, *op. cit.*

During the course of the experiment, *A* noted that his eyes did not adapt themselves readily to the dark,[6] consequently typical reactions were not obtained, as the white disc which served as a location point was not always visible. This condition was never fully corrected though what should have been ample time[7] was allowed for full adaptation to the dark. Then *A* had lost much of his interest in the experiment because of pressing duties away from the university,[8] and tended to assume a passive attitude and concern himself with his own thoughts (as introspection revealed), the reaction process being nearly reflex. But when distraction was introduced, the change to more difficult conditions made it necessary, in order to make a creditable reaction at all, to give more attention to the stimulus and the movement. Thus the time would be shortened by the distraction. Note the similar effect of the distraction after practise on E and F. (See pp. 45 and 78.)

When sound distraction was introduced in the second series the disturbance due to poor adaptation to the dark was eliminated, and at this time *A* was also relieved from over-pressure of work. The distraction effect is seen in all cases but one. But it is not safe to conclude that sound is necessarily a better distraction than light; for it seems rather that the effort required to make a reaction was not so great with sound as with light distraction.

From *A*'s results we may conclude (1) that light, sound, and touch distractions all affected the reaction time; (2) that there was a very noticeable decrease in the influence of light as a distraction due to the long period of practise and the personal characteristics of the subject, his change in attitude, over-training, staleness, or failure to observe instructions.

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[5] As the first series was taken to a stimulus without distraction, this lack of quick adjustment cannot be attributed to the distraction. It was a purely personal characteristic.

[6] Wells, *Psychol. Rev. Mon.* 15, No. 5, p. 40.

[7] For complete adjustment to dark about 20 minutes are required but as the room was dimly lighted so much time was hardly necessary. The time necessary seems to be a matter of individual differences.

[8] The fact that this period was preceded by nearly four thousand reactions may have influenced this change in attitude. Over-training and a "stale" condition may have aroused this attitude.

Subject *B* had the same training as *A*, though he was an experienced subject. The reaction time was shorter with distraction than without it in about a sixth of the cases when light was the distraction, in about half of the cases with sound distraction, but never when touch was the distraction, in spite of all the previous training with the other two distractions.

A few notes from the introspections and observations of this subject reveal a typical condition. When the records from which the ratio .99 was derived were made (Feb. 28), he reported that while making the simple reactions to light he was in a state of complete confusion. He seemed to have no idea just when the stimulus would appear. "The stimulus was there, then I had to get ready and react." During the course of the experiment he adjusted himself, though he still reacted with effort when light distraction was applied. After a rest of about ten minutes, the second series was made, in which the ratio was 1.08.

It seems that *B*, because of his previous experience, reached his physiological limit toward the end of the series of reactions to light with light distraction. *A*, not a practised subject, continued to improve, and was spurred on to do better and better, though, after a time, his simple reactions tend to become mechanical and not to show further progress. But the novelty of the distraction experiment broke up this tendency to automatism and even led to further improvement in the simple reaction time (see the gen. aver. of the last two series for *A*).

B, on the other hand, being near his physiological limit, was necessarily disturbed by the novel conditions of distraction. When touch distraction was introduced, however, there was a further increase of the simple reaction time of both *A* and *B*.

(*b*) Subjects *C* and *D* had both had some experience in reacting, *D* more than *C*. Both became adjusted quickly and easily to the experimental conditions. The distraction effect is very noticeable, but is overcome to some extent as training progresses. (For subject *D*, the ratio of 1.27 on February 12 is not characteristic. The simple reaction time was very low, the distraction time very high, hence the high ratio. The record of the previous day is 1.04.)

C's reactions are remarkably uniform, although the distractions were effective when first introduced. The distractions did not cause any decided "set-back" in the reactions. The figures for the "relative variability" show the effect of practise in their gradual decrease.

(*c*) Subjects *E* and *F* had a slightly different training from the other subjects. Before any distraction was introduced, there was a period of practise in reacting to sound without distraction. This practise was continued till the physiological limit was apparently reached. This period of training should eliminate the practise effect, and make the subjects familiar with all the details of the experiment. Any changes noted in later periods when distraction is introduced will probably be due to the influence of the distraction.

At the close of this first training period subjects *E* and *F* began reacting to the same sound stimulus as before, but with sound distraction present. The distraction was later changed to light, and finally to touch. Thus the order from the close of the first training period was identical with that of *C* and *D*.

There are several cases in *E*'s records in which the "ratio" sinks below 1.00, and in which, accordingly, the distraction had apparently a facilitating effect. Regarding these, however, the following remarks are in order:

On March 9, with sound distraction, the ratios 1.01 and .96 were obtained in two successive series. The subject remarked that he noticed the distraction more and more as the series progressed but was not greatly confused by it.

On March 17, with light distraction, the ratio of .98 would become 1.04 if the first set of simple reactions, with the high average time of 137.0 σ, were eliminated from the control record. If this correction were made, the following ratio of 1.04, made on the same day, would rise to 1.09.

On March 21 and 22 occur four ratios less than 1.00. They would be raised above 1.00 if the control average were taken from the last set of 10 simple reactions before distraction was introduced, instead of from the whole series of 50 simple reactions made at the beginning of the day's experiment. Though this method of determining the control average has not been adopted, it could be defended on the ground that it represented best the simple reaction time for the day after warming-up had occurred.

On March 22, with touch distraction, occur four ratios less than 1.00. Here it is to be remarked that, owing to unavoidable circumstances, several series were made on one day, and with but a single control series. The distraction series show considerable improvement throughout the day's work, and probably the simple reaction would have showed a like improvement, and the ratio thus maintained at about the level that it had at the beginning of the day's work (1.06 and 1.02).

The record of subject *F* also shows several low ratios. The ratio .95 with sound distraction (March 19) is not to be treated too seriously, although the P.E. is but .8 σ. The record following was made the same day and is a better representation of normal conditions. In the first case the distraction was felt as a very strong factor and the subject tried hard to overcome this, but in doing so made nine premature reactions. In the second case these did not occur.

With light distraction the ratio .99 on March 20 is due to one long set of simple reactions occurring in the control series, without which the ratio would be 1.02. On March 24, the ratio .96 occurs twice. The simple reaction time was very long on this day, 121.4 σ, P.E. 2.0 σ. The subject stated that at the beginning of the day's experiment he could not keep from thinking of irrelevant things; but distraction helped to keep his mind from wandering. The ratio .97 on March 25 is probably due to the tendency to premature reactions, five of which occurred. Though the premature reactions did not enter into the averages, the fact that the S even took a chance occasionally might tend to shorten the time.

These erroneous reactions may operate in one of two ways; some persons shorten the average reaction time by taking the chance of incurring some errors, and others are hampered by the occurrence of an error, become over-cautious and lose time in hesitation. Thus premature reactions may signify a gain to some and a loss to others.[9] Subjects *E* and *F* had shorter reaction time when premature reactions occurred, but subject *A* was much disturbed by them. Most of this tendency to premature or synchronous reactions occurred when the distraction was present, and with subjects of the motor type of reacting.

It is well to note that neither *E* nor *F* was working at maximum capacity while reacting to sound alone. Very soon after the sound distraction was introduced, the time of reacting to sound decreased materially and continued throughout on this lower level.

3. *General Statement.*—The tables for subjects *A*, *B*, *C*, *D*, *E* and *F* show series of reactions with and without the distraction from day to day, and also the general average of each of the series. Reference to these averages will show the general effectiveness of the distractions used. *That the distractions were true distractions can not be doubted.* But few exceptions occurred where this was not true. Some of these cases were evidently due to chance; others to definitely known causes.

The effectiveness of the light distraction with the stimulus light is partially hidden in the case of subject *A*. This was partially due to the erratic nature of the subject and his inability to make quick adjustment to experimental conditions. His period of adjustment occasionally extended throughout the entire control period. Thus the control test would be too high and as a result the effect of the distraction in the second series would be lost. This may have been the case with subject *B* in the series with sound as a distraction. *B* indicated that he did not react well in the beginning of some series but did not known the reason for it.

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[9] Seashore, *Iowa Studies in Psychol.*, 1899, **2**, 67.

Subjects *E* and *F* may have failed at certain times to follow instructions carefully. Both noted an occasional tendency to react prematurely. It is possible that the distraction may have served unawares as a sort of preparatory signal. These conditions were not general, but probably occurred just frequent enough to narrow the margin between the control and the distraction series.

Introspectively, all the subjects felt a decided feeling of strain and annoyance when distraction was introduced. Any tendency to make a mechanical or reflex reaction was prevented, at least temporarily. This was the strongest influence of the distraction which the subjects noticed. As soon as the distraction was introduced the subject felt confused. There seemed to be no opportunity to establish any definite order, or rhythm. The distraction and stimulus were not confused, but the time of the stimulus could not be anticipated. Amid the confusion the stimulus appeared and the subject then had to react. But this, of course, is the influence which we attribute to any distraction. Just as soon as the extraneous stimuli fall into a more or less definite order or sequence they cease to distract us.

4. *Effect of Practice on the Distraction.*—Practice lessened the influence of the distraction, but never wholly overcome it. Reference to the curves 3 to 8 constructed from the data of Tables I. to XVII. will show the rapidity with which the subjects lessened the influence of the distraction. Some subjects required more practise than others to reach a similar proficiency in ignoring the distraction. The distraction had the greatest influence at the beginning of practise, with the first series. With practise this influence waned very rapidly till 800 to 1,000 reactions had been made, after which further practice had very little effect on the influence of the distraction.

The figures show that practise influenced both the series without distraction and the series with distraction but the effect was much more noticeable at the beginning of the latter series than of the former. However, after this initial period of rapid improvement the effect was similar in the two series.

5. *Effect of Practise on Trained Subjects.*—To determine more definitely the effect of the distraction from the very time when it was introduced, two subjects, *E* and *F*, were given practise in

reacting to a sound stimulus without the distraction. Adaptation to experimental conditions would thus occur within this first practise period, and, when the distraction is introduced what change occurs must be attributed to the distraction.

After *E* and *F* had reacted to the sound stimulus till no further gain seemed possible, the sound distraction was introduced. After practise with this distraction, the light distraction was introduced, and later, the touch distraction was used. Hence, there is a series of simple reactions to sound, a series of reactions to sound with sound distraction, a series to sound with light distraction, and a series to sound with a touch distraction. These last three series are also accompanied by a series of simple reactions for a daily control series. See Tables XI. to XVII. and figs. 7 and 8.

So far as type of reacting is concerned here, *E* and *F* were very similar individuals. Both were more or less erratic at certain periods during the experiment.

In the first practise period adjustment to the experimental conditions occurred quite rapidly, and although the adaptation is not uniform, both subjects apparently reached a limit before the series was closed.

When the first distraction was introduced a peculiar change was noted. Practise not only reduced the reaction time with the distraction, but the control series with no distraction was further reduced. This may be a true practise effect, but it seems more likely that the careful attention and intense effort necessary to react with the distraction present became a permanent asset and thus aided in improving the other reactions. This would indicate that the subjects had not been working at their maximum ability. When the distraction was introduced a change in attitude occurred and henceforth the work was performed on a higher plane of efficiency.

When distraction was introduced, the distracting effect was not so great with subject *F* as with subjects *A*, *B*, *C*, and *D*. The variations were not so great for *E* and *F* as for the other subjects. Otherwise, *E* does not seem to have gained from his practise period without distraction. The same general practise effect occurred within his first 1,000 reactions as was noticed with *A*, *B*, *C*, and *D*. This was not true of *F*. He had eliminated this period by his previous practice. *A*, *B*, *C*, and *D* had to accustom themselves to experimental conditions, and also to withstand the influence of the distraction. *E* and *F* had these factors singly to contend with. For this reason much of the great variability in the early part of the practise period is eliminated. The distraction effect seems to be greater with an unpractised than with a practised performance, though this point needs further investigation.

VII. THE "WARMING-UP" PERIOD

The "warming up" or incitement period seems fairly characteristic of the work curve of most individuals but Thorndike believes that its importance is commonly exaggerated.[10] The period is usually short and occupies only the first few minutes of the experiment.

In the present experiment the warming up period was characteristic of the simple reactions and present to a less degree in the reactions with distractions. (See Tables XIX. to XXV. and curve 9.)[11]

The very first part of the work would suggest an initial spurt. The subjects decreased gradually in efficiency in reacting during the first few minutes then seemed to recover and gradually improve to the end of the period. When distraction was introduced this same type of reacting was present in a less marked degree.

This "warming-up" period was not uniform with the different subjects in the amount of time required. This irregularity of adjustment to experimental conditions in the simple reactions has probably hidden some of the real influence of the distraction in the second series. It will be remembered that fifty simple reactions were taken at each period as a daily control. The distraction was then introduced, the stimulus remaining the same, and one hundred reactions taken. If the subject failed to get "well set" in the experiment until about the end of the simple reaction series the average of these fifty reactions would necessarily be higher than the normal reaction time. By the time distraction was introduced, the subject would be fairly well adapted, so that his reactions would be influenced by nothing but the distractions, but how much this influence amounted to could not always be shown, as the simple reactions were unduly influenced by the warming-up period. A great number of reactions, however, will tend to eliminate some of this influence.

Some experimenters have followed a definite method in eliminating reactions which seem affected, or discordant, by observing the variability in each case. Cattell and Dolley[12] state their method as follows: "In each series we made thirteen reactions, and rejected the time which departed most from the mean, then the time which departed from the mean of the remaining twelve reactions, and finally the third most discordant reaction. We thus had the mean of the ten most accordant reactions, which would represent a compromise between the median and the mean."

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[10] "Educ. Psychol.," III., 67.

[11] The time required for "warming up" and adaptation depends upon the individual, and varies from day to day. Usually, a long "warming up" period may be associated with the individual who cannot eliminate extraneous influences from the experiment. Often these influences are nothing more than his own thoughts.

Holman rejected the supposed mistake if its deviation was greater than four times the average deviation of the other measurements.[13]

Since it was the effect of the distraction which we were attempting to measure, all reactions were recorded, and only those were eliminated which the experimenter knew were wrong or which were reported as wrong by the subject. Only a few were eliminated and these omissions are indicated in the tables.

VIII. Temporary Adaptation to the Stimulus

Tables XIX. to XXV. give the average daily performance throughout the series both with and without distraction. Fig. 9 is based on these tables. The short "warming-up" period was characteristic of each set of daily reactions both in the control set of fifty reactions and in the one hundred reactions with distraction present. This period of adaptation was much more noticeable in the beginning of the experiment than near the end. The adaptation was much slower in the daily control test than with distraction present. There are two reasons for this: (1) The adaptation in the first series prepared the subjects fairly well for all the work which followed. (2) Reacting with the distraction present required a better type of attention. The subjects found that more effort was required and so gave more attention to the work. This factor coupled with the desire of the subject to succeed as well as when no distraction was used caused a very rapid adjustment in the series with distraction.

1. *Daily Work Curve.*—Further evidence of the disturbing effect of the distraction was found within the daily work curve. These curves seem typical of the kind of work performed. There is also a great similarity among the individuals who had the same special training.[14]

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[12] *Op. cit.*, p. 402. Poffenberger began his computations by using this same method but found that the corrections made but little difference in the results. *Op. cit.*, p. 43.

[13] "Discussion of the Precision of Measurements," N. Y., 1892, p. 30; Bliss, *Yale Studies*, 1892–3, **1**, 18.

[14] The data of which the curve is a graphic representation appear in Tables

These curves indicate at a glance whether the distraction functioned most as a disturbance in the beginning of the day's series, at the close, or was general throughout the period.

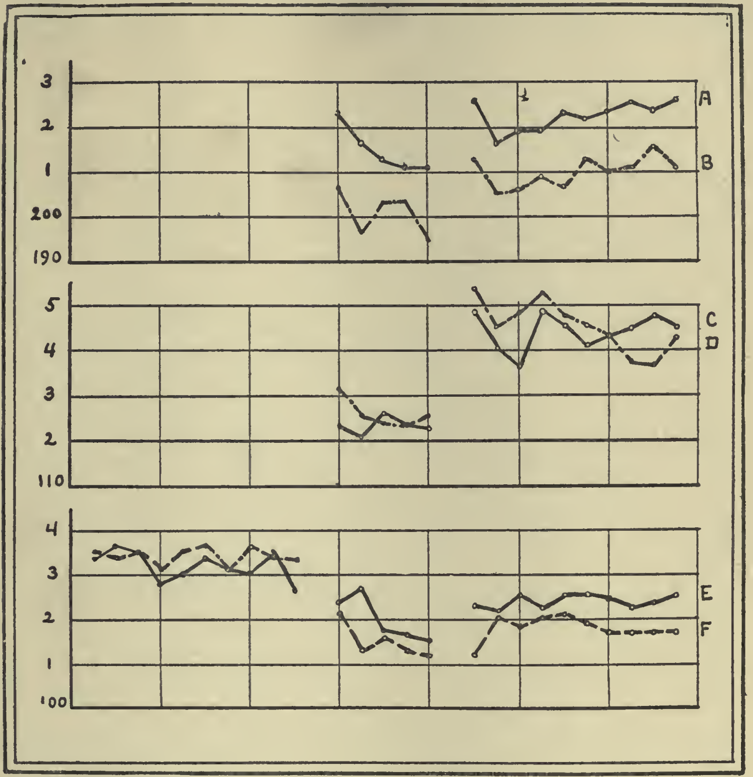

Fig. 9. Graphic representation of Tables XIX to XXV.

In the reaction time without distraction there was present in most cases a general "warming-up" at the beginning of each series.[15] When the distraction was introduced, the reactions were lengthened, but in the second set of 10 there was partial recovery. From this

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XIX. to XXV. Each point on the curve is an average of the averages of the ten reactions made at a given part of the sitting. Column one represents the average of the first set of ten in all the sittings. Column two, the average of the second set, etc. In brief, the curve is a composite daily work curve. Reference to Table XVIII. will make this formation clear.

[15] Cattell observed that the first reactions of a series are the shortest. It seems that in the first experiments the observer involuntarily strains his attention more and so gives shorter times. This is more marked the less automatic the process is. *Mind*, 1886, **11**, 537.

point there was a gradual slowing of the reactions, most noticeable with *A* and *B* and least with *D* and *F*.

The clearest representation of the distraction may be had by observing the last point in the first curve and the first and last points in the second curve for each subject (Fig. 9). *In every case, without exception,* the points in the last curve are widely separated from the last point of the first curve, and in most cases from the first point.

There was no evidence to show that the waves or irregularities in the curves were due to any particular physical cause. Indeed, irregularities would be expected since the product of the nervous system is a variable quantity. If these curves approached a straight line, an explanation would be demanded.

The gradual increase in the reaction-time throughout the sitting may suggest fatigue, but it is difficult to believe that fatigue played a part in so short a time as that required to make one hundred and fifty reactions, interspersed with frequent rest periods of about ten seconds each. The fifteen sets (five to simple stimulus and ten to stimulus with a distraction, 150 reactions in all) never required more than twenty-five minutes including the rest period of about ten minutes. Usually less time was required. It is doubtful if any marked tendency toward fatigue would occur within this short period with so reflex an act as the reaction tends to become in practised subjects. Cattell[16] found that the effect of fatigue was slight even when reacting almost continuously (15–20 hours) throughout the whole day. Bettmann found[17] that in making choice reactions for about two hours, in which two thousand reactions were made, the reaction time was increased only about 25 σ. Poffenberger and Todd reacted almost continually for two hours or more to rapidly appearing stimuli. They found the effects of fatigue absent or very slight.

If an increase in the variability is indicative of fatigue,[18] it is impossible to infer fatigue from the observed variations, which show a somewhat general decrease from the beginning, due to the practise effect, and no other general tendency. It is not proper to treat the occasional high deviations which occur in some records as evidence of fatigue. These, no doubt, are due to chance. The subject is not well adapted, he is more easily disturbed than on other occasions, he has changed his attitude, or has hit upon some little device, or is deeper in the old rut at this special time when the high variability occurred. The elements of the so-called mental and general fatigue in ordinary life seem to be inability to attend, headache and sleepiness, but headaches seem more frequently a result of mental, and sleepiness of muscular work. At the close of each sitting, the subject reported his type of attention and his physical condition, rating each as excellent, fair, or poor. In so far as these remarks may be taken as indicative of conditions, no fatigue was noted. Some subjects even reported that their condition had improved during the experiment, although the reaction times had increased in length. No one reported that attention could not be given to the experiment. When light was the distraction, the subjects occasionally reported a sensation of sleepiness, a partial hypnotic state. If we must consider feelings of annoyance and of desire to stop the experiment as indicative of fatigue, then fatigue was undoubtedly present, as it would be in any task pursued for any noteworthy length of time. The retrospections indicate that fatigue, as usually understood, was not present.

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[16] *Mind,* 1886, **11**, 536–537; Wundt's *Phil. Studien,* 1886, **3**, 489–492.

[17] *Kraepelin's Arbeiten,* **1**, 156.

[18] Thorndike, "Educ. Psychol.," 3, p. 11, 12, 1914.

In prolonged exercise of any function, the two opposing elements of practise and fatigue enter. In this experiment the effect of practise was minimized by the fact that some of the subjects were previously trained, while all received a long period of training at the beginning of the experiment. It also seems safe to conclude that fatigue was not present enough to influence the time of reacting to a noticeable extent. What change did occur in the course of a sitting must accordingly be due to the influence of the distraction.

2. Tables XIX. to XXV. give a composite summary of the work of the different practise subjects. The data were derived from tables similar to Table XVIII. for *C*. Each sitting began with five sets of 10 reactions without distraction. The averages of these sets are shown in the first five columns. The subjects then made ten sets of 10 reactions to the same stimulus as before but with a distraction present. The averages of these sets are shown in the last 10 columns. The average at the top of the table represents the general average for all the single sittings, the number of which is shown in the parenthesis; *e. g.*, 35 in parenthesis means 35 sets of 10 reactions each, or a total of 350 reactions. The first set of figures beneath the average is the M.V.; the second set the P.E. The general average at the bottom of the table is obtained, not from the single sittings directly, but from the three averages made with the three different distractions. Much of the variability has been eliminated from this latter group as it is not so weighted as the other averages. For this reason it probably throws the weight of evidence where it naturally belongs. The first general averages, however, were used in all the comparisons. The second, third, and

fourth lines represent the averages of the reactions without and with the special distraction.

E and *F* had a period of training in making simple reactions to sound. These were made in sets of 10 reactions each. The average of these sets is given in Table XXV. No reactions with distraction were made during this training. The results of Tables XIX. to XXIV. are summarized in Table XXVI, only the general averages of the individual sets being here given, with the M.V. of correponding sets, the P.E. for the average values of the sets, and the number of sets going to make up the averages, in the three lines below. (See Table XXVI, p. 88.)

TABLE XXV.

AVERAGE SIMPLE REACTION TIME TO SOUND FOR SUCCESSIVE SETS OF TEN REACTIONS

Subject E

133.5	136.6	134.5	128.9	130.9	133.4	131.7	130.9	135.3	128.3
6.1	**9.8**	**9.8**	**8.4**	**7.2**	**6.8**	**4.9**	**9.8**	**5.5**	**6.8**
1.4	*2.2*	*2.2*	*1.9*	*1.6*	*1.6*	*1.3*	*2.5*	*1.4*	*1.7*
(13)	(13)	(13)	(13)	(13)	(12)	(10)	(10)	(10)	(10)

Subject F

135.1	133.9	134.1	131.1	133.1	134.1	131.1	134.8	134.9	132.5
9.1	**9.7**	**11.3**	**9.3**	**11.8**	**11.5**	**10.5**	**11.1**	**12.9**	**10.3**
1.6	*1.7*	*2.1*	*1.7*	*2.2*	*2.2*	*2.0*	*2.1*	*2.4*	*1.9*
(21)	(21)	(21)	(20)	(20)	(20)	(20)	(20)	(20)	(20)

3. To show the effect of practise and distraction in a rough way, the series of one hundred reactions made each day during the experiment has been divided and the average of each half determined. This has also been done for the fifty reactions used as a daily control and taken just previously to the introduction of the distraction. Table XXVII. shows this comparison.

TABLE XXVII.

	Gen. Av. of Training Series with Sound		*Gen. Av. of the Control Series*		*Gen. Av. of Series with Distraction*	
Subj.	*1st half*	*2d half*	*1st half*	*2d half*	*1st half*	*2d half*
A.........			227.2σ	213.0σ	222.4σ	222.7σ
B.........			205.4	202.1	210.3	214.1
C.........			123.2	121.9	123.3	122.6
D.........			129.9	125.8	149.3	141.5
E.........	132.0	131.0	125.3	117.9	124.1	124.5
F.........	131.2	155.0	116.8	114.4	121.1	120.6

E and *F* had a period of practise in reacting to a sound stimulus without the distraction. This practise series was followed by the same training that *C* and *D* received. The first two sets of figures are the averages of the first and second halves of this series without the distraction.

The subjects improve within the sitting quite rapidly making simple reactions, but when the distraction enters the improvement is not so marked; in fact, the influence of the distraction is felt as much in the second half of the period as in the first half. The table also shows that fatigue was not a strong factor.

IX. THE MOST EFFECTIVE DISTRACTION

It is impossible to make a dogmatic statement here as we must consider the distraction effect from more than one point of view. The "most effective distraction" may mean that which affected the reaction-time by the greatest amount, or that which affected it for the longest period, *i. e.*, which was most difficult to overcome.

1. If we take the average excess time of the series with distraction over the series with no distraction (the daily control series) for all the subjects in the practise group, we have the following, the greatest difference indicating the greatest distraction effect.

Sound	*Light*	*Touch*
14.9σ	13.8σ	7.8σ

From the above may be noted the similarity of sound and light as distractions. Touch seems inferior if amount of effect is considered. But it should be remembered that touch was the last distraction used, and that, for this reason, the subjects were better trained when they began the touch series than with light and sound.

2. If the first part of each series with light and sound distraction is omitted in the practise of *A* and *B*, and *C* and *D* a better comparison seems possible. This order is as follows:

Sound	*Touch*	*Light*
12.5σ	7.8σ	5.3σ

As the longest reactions occurred with *A* and *B* in the very beginning when light was the distraction, the elimination of these accounts for the shift of light to the end of the above series.

So far as amount of difference is the criterion for determining the most effective distraction, sound is first, light second, and touch last. But this is a gross comparison and must not decide the question.

3. The general average of the ratios or relation of the distraction series to the series without distraction gives another comparison (see Tables I. to XVII.). Thus we have the following:

TABLE XXVIII

STIMULUS, LIGHT

		Distraction	
	Sound	*Light*	*Touch*
A	1.01	1.00	1.06
B	1.00	1.06	1.04
Gen. Av.	1.01	1.03	1.05
		STIMULUS, SOUND	
C	1.15	1.13	1.08
D	1.14		
E	1.12	1.01	1.01
F	1.07	1.01	1.04
Gen. Av.	1.12	1.05	1.04

By this comparison, little difference appears between the specific effects of the three distractions.

4. The variability of the reaction time in the preliminary and final control tests for the two groups of subjects may be an index of the amount of distraction. Higher variability probably indicates more distraction effect (see p. 69). The table below shows such a comparison.

TABLE XXIX

PRACTISE GROUP

		Distraction	
	Light	*Sound*	*Touch*
Prelim. Test	.077	.055	.039
Final Test	.046	.051	.044
		CONTROL GROUP	
Prelim. Test	.065	.067	.071
Final Test	.055	.042	.048

5. The results below are the average excess of the reaction time with distraction over the time without the distraction in the preliminary and final control series.

TABLE XXX

CONTROL GROUP

	Sound	*Light*	*Touch*
Prelim. Test	33.0σ	22.4σ	21.5σ
Final Test	34.9	26.0	17.6
Gen. Av.	33.9	24.2	19.5
A.D.	10.0	1.8	2.0
P.E.	*0.6*	*1.1*	*1.2*

Practise Group

	Light	*Touch*	*Sound*
Prelim. Test	29.2σ	25.8σ	25.7σ
Final Test	13.0	16.4	10.9
Gen. Av.	**21.1**	**21.1**	**18.3**
A.D.	8.1	4.7	7.4
P.E.	*4.7*	*2.7*	*4.3*

6. The distraction which worked most frequently, though the effect was small, is in a sense the most effective distraction. The evidence on this point is not uniform, but, a decided distraction was caused in the following percentage of cases:

Sound, 89 per cent.; Touch, 82 per cent.; Light, 64 per cent.

7. According to the introspections of the subjects (not offered as conclusive proof) the distractions were effective in the following order:

Sound, Light, Touch.

The subjects were soon able to ignore entirely the touch distraction (although the reactions showed that it was still effective), but this was not true with the sound distraction, and the subjects felt most of the time that the sound was actually "beating in" on them.

Conclusion.—It seems warranted from these last comparisons, although the differences are small, to state in conclusion that sound was most effective as a distraction. The author does not wish to include the first comparisons in this statement, as they are very general.

Swift obtained somewhat different results from the above, perhaps because of a difference in the disturbance used, which in his case was intermittent and appeared one hundred and twenty times per minute. "When the disturbance and excitation affect the same sense, a distraction of the attention through the sense of sight has more influence upon the reaction-time than the same grade of a disturbance through the sense of hearing."[19]

The strong distraction effect of sound—if we may accept it as proven—may be related to several other facts: the quick reaction to sound, the special liability to false reactions to intercurrent sound stimuli,[20] the reflex start which is evoked by sudden noises, and the poor localization of sounds. The distracting influence of sound may operate primarily at the reflex level. The nervous mechanism for reactions to the sense of hearing, as to the sense of touch, has been primarily a protective mechanism. Though we tend to think of touch as the chief protective sense, hearing, phylogenetically more recent, has perhaps taken its place as the chief means of protection. Sight, typically, informs us of danger from which there is ample time to escape, and touch of danger from which, if it is serious, we can scarcely escape by simple protective reactions, while hearing tells us of dangers from which escape is possible by quick reaction. The heard danger is near and demands promptness, and by natural selection a short and direct neural path for reactions to sound has been established. Sudden sound stimuli therefore act on us with a compelling force and can not be easily disregarded.

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[19] *Amer. Jour. Psychol.*, 1892–3, **5**, 12–15.

[20] Bliss, "Reaction-time and Attention," *Yale Studies in Psychol.*, **1**, 39.

But, more than this, whereas localization of visual and tactile stimuli is prompt and precise, and the instinctive reaction to them correspondingly localized, sounds are more slowly and vaguely localized, and the first reaction to a sudden sound is a "start," which bears no relation to the source of the sound, except that the sound is reacted to as if near. Sound raises a problem of localization which does not immediately resolve itself; and, hence, perhaps, its hold on us and its strong distracting effect.

X. Is the Distraction More Effective when Belonging to the Same Sense as the Stimulus or to Another Sense?

By using the average of the ratios in Tables I. to XVII. the following comparison may be made.

TABLE XXXI

Same Sense

Subject	*Stimulus*	*Distraction*			
A, B	Light	Light	1.04		
C, D, E, F	Sound	Sound	1.12		
		Av.	1.08.	A.D.	.040
				P.E.	*.024*

Different Sense.

Subject	*Stimulus*	*Distraction*			
A, B	Light	Sound	1.01		
"	"	Touch	1.05		
C, D, E, F	Sound	Light	1.02		
"	"	Touch	1.04		
		Av.	1.03	A.D.	.015
				P.E.	*.006*

A comparison with touch can not be made, as a series for touch was not made. But even if we eliminate the touch distraction from this experiment the comparison remains unchanged.

The comparison indicates that the distraction is more effective when belonging to the same sense as the stimulus.[21] Of the distractions not belonging to the same sense as the stimulus, touch seems the most effective.

When the stimulus and the distraction both belong to the same sense there is always some similarity between the two, and thus a slight discriminatory tendency probably arises. This is especially true with sound which is very distracting, due to the inability of the ear to localize sounds definitely. Localization in the case of light and touch, if needed, are more accurate.

XI. Conclusion

1. All the distractions affected the reactions by making the time longer.
2. The period of greatest distraction occurred at the beginning of the series. Light distraction caused the greatest distraction at the beginning, but its influence waned rapidly.
3. Practise caused an early period of rapid adaptation to the distraction. This was followed by a period of much slower adaptation.
4. The effect of distraction was never completely overcome.
5. The first practise period reduced the time of the other series of reactions about 50 per cent.
6. The distraction lengthened the time of reaction of both trained and untrained subjects.
7. A period of adaptation was noticeable in the daily work in the series with no distraction, and in the series with distraction.
8. The relative variability of reaction with no distraction is smaller than the reaction with distraction (see p. 69).
9. The distraction effect not only influences the reaction time with distraction but also the series of reactions without distraction.
10. Sound was on the whole a somewhat more effective distraction than light or touch.
11. The distraction effect was greater when the distraction and main stimuli belonged to the same sense than when to different senses.

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[21] Earlier investigation has seemed to indicate that the reactions are more influenced through a disturbance of the attention if the excitation and disturbance affect different senses than when both are of the same nature, but this experiment does not sustain this view.—Swift, "Distraction of the Attention," *Amer. Jour. Psychol.*, 1892–3, 5, 14–15.

CHAPTER VI

TRANSFER OF TRAINING

In educational discussions of "formal discipline," as well as in psychological discussions of the experiments on "transfer," the conception of *training the attention* has often been introduced; but there has been little if any direct experimentation on transfer as related to training of the attention. Now since attention consists partly in resistance to distraction, training in resisting a specific distraction constitutes a specific training of attention, and the transfer effect can be examined when other distractions are substituted for the one employed in the training.[1]

I. Experimental Procedure

Six subjects, as described in the previous chapters, went through an extensive course of training in reactions to light or sound stimuli, both with and without certain distractions. Before and after this training, these six subjects (*A*, *B*, *C*, *D*, *E*, *F*), and also a control squad of five (*V*, *W*, *X*, *Y*, *Z*), were tested in reacting to light, sound and touch stimuli, with and without distractions. Comparisons designed to show the effects of specific training can be made (*a*) between the practise and control groups, (*b*) between different subjects belonging to the practise group, since *A* and *B* were trained with light, and *C*, *D*, *E* and *F* with sound as a stimulus, and (*c*) between the initial performance of each of the trained subjects, and his performance on shifting to a modification of the experiment after he had received some part of his special training.

The instructions throughout required the subject to react as quickly as possible, and give special attention to anything except the designated stimulus. These simple directions were emphasized enough to make them a sort of ideal.

In the preliminary and final tests, the same stimuli with the same accompanying distractions were presented to the subjects in both the practise and the control groups in the same identical sequence. (See p. 34 for the order of procedure.) Approximately one hour each was required for the preliminary and final tests, including the rests which were interposed after each of the series of reactions. So far as introspections reveal, no fatigue was present, and the attitude of all the subjects was excellent.

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[1] The recent survey of the literature of transfer by Thorndike in his "Educational Psychology," 1913, Vol. II, pp. 350–443, makes it unnecessary to insert a historical note on the subject. See also a still more recent, brief survey by Martin, in his "Transfer Effects of Practise in Cancellation Tests," *Archives of Psychology*, No. 32, 1915.

II. Results of the Preliminary and Final Tests

Tables XXXII. to XLII. give the achievement of the control and practise groups in the preliminary and final tests. Each entry represents the average of fifty reactions. Under "P.C." is given the Pearson coefficient of variability. The "Gain or Loss" includes two items. The first column gives the gain or loss made by the subject in reacting. Gain here means a decrease in reaction-time. No sign is used when a gain is made. A negative sign indicates a longer reaction-time in the final test than in the preliminary test. The last column gives the difference in variability between the two tests.

Figs. 10 to 20 give a graphic representation of Tables XXXII. to XLII. The unshaded part represents the achievement made by the subjects in the preliminary test; the shaded area the achievement made in the final control test. Between the two control tests *A*, *B*, *C*, *D*, *E*, and *F* had a period of practise, the data for which are given in Tables I. to XVII.

Tables XLIII. and XLIV. represent the gain or loss made by the practise group and the control group. The first set of figures is the gain or loss made in the reaction time. The second set is the increase or decrease in the variability (M.V.). When, occasionally, two figures are given for the same item, the second is the reaction-time which followed just after the reaction from which the first difference was obtained.

To obtain the average gain for the whole group the gains for the individuals were added algebraically. A negative sign indicates a longer reaction-time in the final test than in the preliminary test. A summary of the average gain or loss is given under its proper heading. The M.V. accompanies each average.

III. Training in Simple Reaction to one Stimulus Shortens the Simple Reaction to Another Stimulus

The gain shown by the practise group in simple reaction to that stimulus with which they had been trained is here brought into comparison with their gain in reacting to another stimulus, and also with the gain (or loss) of the control group.

The upper half of Table XLV. shows the gain made by the sub-

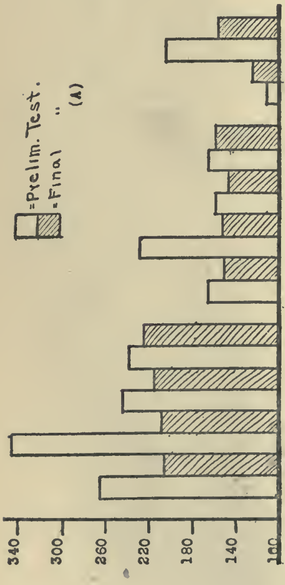

Fig. 10.

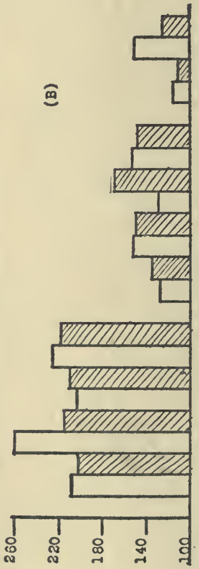

Fig. 11.

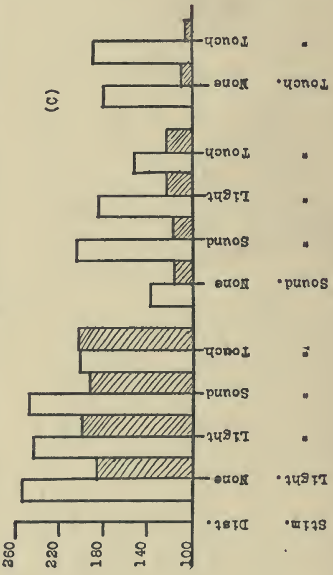

Fig. 12.

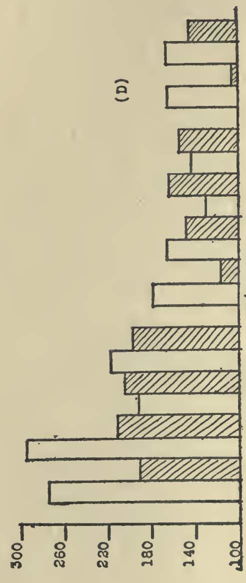

Fig. 13.

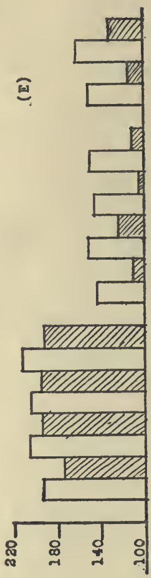

Fig. 14.

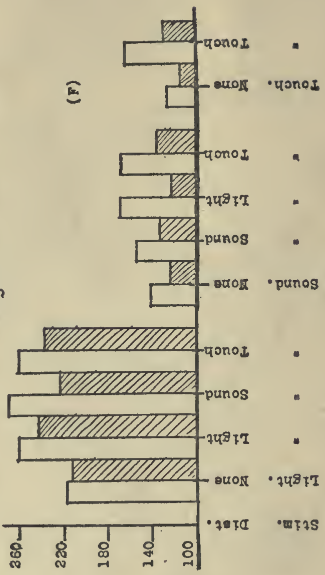

Fig. 15.

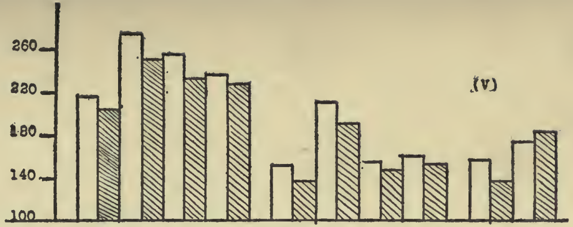

Fig. 16

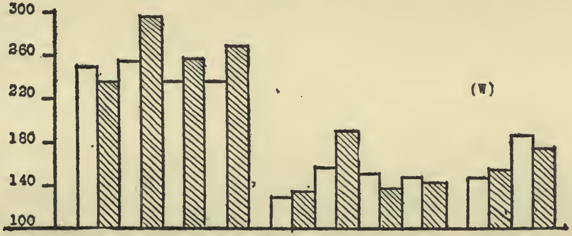

Fig. 17.

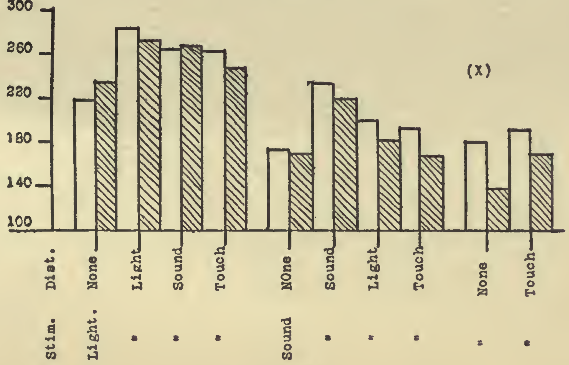

Fig. 18

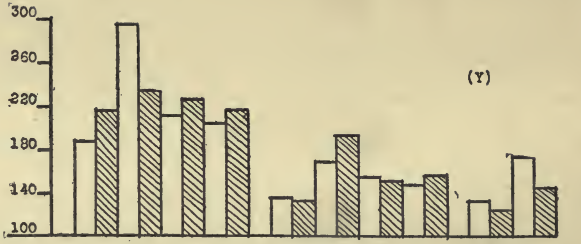

Fig. 19.

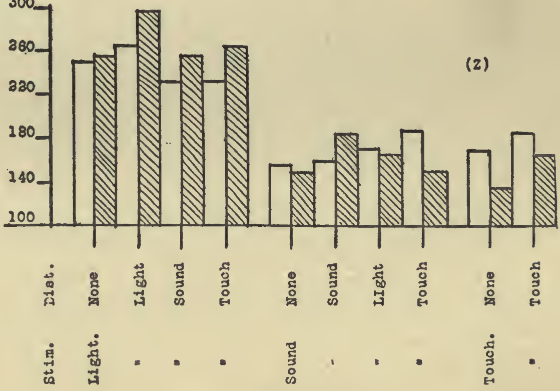

Fig. 20

jects in reacting to a stimulus through practise. The lower half of the table shows the gain made in reacting to a different stimulus as a result of the practise in reacting to the first stimulus. The subjects are divided into two groups according to the stimulus used. Under "Diff. in time" is given the difference between the preliminary test and the final control test. The last column indicates the difference in variability between the two series. A positive sign indicates that the series in the final control test were shorter than the series in the preliminary test. This is a gain. A negative sign indicates the opposite condition.

TABLE XLV

Subject	*Gain in Time*	*Practise group* *Gain in Var.*
	I. Special Training	
	Gain by reacting to light with no distraction. Subjects received practise in reacting to light	
A	+48.1σ	+14.8σ
B	+ 5.5	−11.4
	Gain by reacting to sound with no distraction. Subjects received practise in reacting to sound	
C	+23.8	+15.7
D	+62.3	+ 6.2
E	+30.1	− 2.3
F	+16.1	+ 3.9
Gen. Av.	**+31.0**	**+ 4.5**
	II. Transfer of Training	
	Gain by reacting to sound with no distraction. Subjects received no training to reacting to sound	
A	+27.4σ	+12.4σ
B	− 9.7	+ 2.2
	Gain by reacting to light with no distraction. Subjects received no training in reacting to light	
C	+67.9	+15.7
D	+82.7	+ 6.2
E	+21.9	− 2.3
F	+ 4.8	+ 3.9
Gen. Av.	**+32.5**	**+ 6.4**
	III. Control Group	
	Difference in prelim. test and final test for reactions to light.	
W	+14.1σ	+19.2σ
Z	− 5.1	+ 5.7
Y	−27.7	+ 2.9
V	+17.8	+10.7
X	−18.1	+ 9.2
Gen. Av.	**− 3.8**	**+ 9.5**

Difference in prelim. test and final test for reactions to sound.

W	− 6.2σ	−10.8σ
Z	+10.7	+ 3.2
Y	+ 2.0	+ 4.2
V	+10.2	+ 5.4
X	+ 3.0	+ 6.2
Gen. Av.	+ 3.9	+ 1.6

The ability gained by reacting to a stimulus for a long time seems to be transferred bodily when reactions are made to another stimulus. Table XLV. indicates that a gain of 31.0 σ was made by training with a specific stimulus, and a gain of 32.6 σ when reactions were made with another stimulus without previous training with it.[2]

IV. Training in Reaction with Distraction Shortens the Reaction to a Different Stimulus with the Same Distraction

It was not possible to collect data from all the subjects on this problem lest it invalidate other data of more importance to this study. The data below are for *A* (trained with a light stimulus) and *C* (trained with a sound stimulus).

TABLE XLVI

A made gains as follows:

Stimulus	*Distraction*	*Gain*
Sound	Light	+ 5.8σ
Sound	Sound	+77.3
Sound	Touch	+ 3.1
Touch	Touch	+ 6.0

C made gains as follows:

Stimulus	*Distraction*	*Gain*
Light	Sound	+38.7σ
Light	Light	+32.0
Light	Touch	− 6.3
	Av. Gain	+32.2

V. The Above Questions Examined Specifically in the Case of Reaction to Touch.

This comparison will show clearly the effect of practise in one performance on an unpractised performance. *A* and *B* were trained to react to light, and to light with touch (as well as light and sound) distraction; *C*, *D*, *E*, and *F* to sound, and to sound with touch (as well as light and sound) distraction. Neither group received training in reacting to touch, or to touch with touch distraction. Thus we are able to see what effect reacting to light had on the ability to react to touch; of reacting to sound on the ability to react to touch; and finally what result occurs when no training is given (control group). Table XLVII. gives this comparison. It seems

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[2] While the data are treated as if no other training occurred it must be remembered that the subjects also made reactions to the same stimulus with distractions. Some of the practise gain is due to this training also.

TABLE XLVII

	Stimulus, Touch		*Distraction, Touch*	
Subjects	*Gain in Time*	*Gain in Var.*	*Gain in Time*	*Gain in Var.*
Trained by Reacting to a Light Stimulus alone, and to a Light Stimulus with Light, or Sound, or Touch as a Distraction				
A	− 8.3σ	− 3.9σ	+33.6σ	− 7.1σ
B	+ 5.1	+11.2	+25.7	− 8.5
Trained by Reacting to a Sound Stimulus alone, and to a Sound Stimulus with Sound, or Light, or Touch as a Distraction				
C	+70.8	+27.2	+81.4	+26.7
D	+69.6	+16.2	+17.9	− 6.7
E	+37.1	+ 2.6	+30.7	− 5.2
F	+11.2	+ 4.6	+32.8	−10.6
Gen. Av.	**+30.9**	**+ 9.6**	**+37.0**	**− 1.9**
The following group had no practise				
W	− 6.3σ	− 3.9σ	+ 9.8σ	+ 6.2σ
Z	+30.4	+13.0	+17.7	−22.5
Y	+ 8.6	+ 3.3	+29.7	+22.0
V	+19.2	+12.7	− 7.9	+ 0.3
X	+41.2	+ 5.2	+22.2	+ 8.3
Gen. Av.	**+18.6**	**+ 6.1**	**+14.3**	**+ 6.9**

that familiarity with the touch distraction in other relations is carried over to this combination, as greater gain is shown with distraction present than in the simple reaction—which is not true of the control group. The practice group has certainly profited by its training with other stimuli. Even such gain as is shown by the control group may be due to the fact that the reactions made to touch and to touch with touch distraction were preceded by all the other reactions made in the control tests.

VI. Training in Reacting without Distraction does not Appreciably Aid in Reacting to the same Stimulus with Distraction. (See the Records of *E* and *F*)

During his training in reacting to a sound without distraction, *E* made a gain of 2.5 σ, but his subsequent reactions to sound with sound distraction, and to sound with light distraction were increased

0.5 σ, and 7.0 σ respectively. However, his time of reacting to sound with touch distraction was decreased 4.4 σ.

The reaction-time of *F* to a sound stimulus without distraction was reduced 18.8 σ by special training. This training also reduced his reactions to sound with sound distraction 9.2 σ.

The result here, then, is rather negative. Training in reacting without distraction does not aid much in reacting with distraction; and this agrees also with the introspective reports of the subjects. Other experimenters have noticed that practise received in making simple reactions did not affect the time necessary to react when discrimination was necessary.[3]

VII. Training in Reacting with a Certain Distraction Shortens the Time of Reaction with a Different Distraction

The data for Tables XLVIII. to LIII. were obtained from the preliminary and final tests of the practise control groups. See Tables XXXII. to XLII.

A and *B* reacted throughout the experiment to the light stimulus, and their main practise was with light distraction. *C*, *D*, *E*, and *F* were trained in reacting to the sound stimulus, and their main practise was with sound distraction. The training of *C* and *D* was more extensive than that of *E* and *F*. *V*, *W*, *X*, *Y* and *Z* received no special training, but served as a control group. The tables indicate the gain or loss in both the practised performance and the unpractised performance with the practise group and the corresponding figures from the control group. A positive sign indicates a gain in ability, *i. e.*, the reaction time was shorter at the end of the experiment than at the beginning. A negative sign indicates the opposite condition. The difference in the variability of the two periods is indicated under "Diff. in Var." This difference is the difference between the mean variation in the preliminary test and the mean variation in the final test. A negative sign indicates greater variability in the final test than in the preliminary test. A negative sign in variability is not necessarily preceded by the same sign as the difference in the reaction time. The opposite seems more apt to be true. The subject takes chances. The reaction time is reduced by taking these chances, but the variability is usually increased.

It is obvious from Tables XLVIII. to LIII. that the greatest gain was made in the performance in which the most practise occurred. However, the gain of 75.1 sigma made by *A* when the sound stimulus was present may not be a true representation of *A*'s actual gain. The initial reaction-time which permitted this great gain was 225.8 sigma. As the P.E. was 10.1 sigma it seems, without doubt, to be an eccentric record.

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[3] Gilbert and Fracker, *op. cit.*

Table LIV. was formulated from Tables XLVIII. to LIII. The special training was reacting to light, and to light with light, or sound, or touch distraction (*A* and *B*); and to sound, and to sound with sound, or light, or touch distraction (*C*, *D*, *E*, *F*). The second line represents the gains made by *A* and *B* in reacting to sound, and to sound with sound, or light, or touch distraction; and the gains made by *C*, *D*, *E* and *F* in reacting to light, and to light with light, or sound, or touch distraction. The last line shows the gain made by *V*, *W*, *X*, *Y*, *Z* in reacting to light with light, or sound, or touch distraction, and to sound with sound, or light, or touch distraction.

TABLE LIV

	Without Dist.	*With Dist.*
Gain made by special training....................	$+29.9\sigma$	$+34.1\sigma$
Gain made in reacting to another stimulus as the result of this special training................	$+26.6\sigma$	$+17.9\sigma$
Gain of the unpractised group....................	$+\ 0.05\sigma$	0.0σ

The summary was not made from the separate records of the previous tables, but from the averages of the data in these tables. If individual gains are used, the result is essentially the same, as follows:

TABLE LV

	Without Dist.	*With Dist.*
Gain made by special training....................	$+30.9\sigma$	$+33.3\sigma$
Gain made in reacting to another stimulus as the result of this special training.................	$+32.5\sigma$	$+20.7\sigma$
Gain of the unpractised group....................	$+\ 0.7\sigma$	$+\ 0.3\sigma$

Table LVI. is another summary of Tables XLVIII. to LIII. The averages here represent the general average of the individual records.

TABLE LVI

	Av. Gain In Time	*Av. Gain In Var.*
Most trained performance......................	$+57.4\sigma$	$+\ 8.3\sigma$
Same performance with the untrained............	$-\ 2.1$	$+\ 3.0$
Less trained performance......................	$+22.0$	$+\ 9.1$
Same performance with the untrained............	$+\ 1.1$	$+\ 3.3$
Performance with no previous training in it........	$+20.6$	$+\ 7.4$
Same performance with the untrained............	0.0	$+\ 3.2$

The most trained performance was in reacting to light with light as a distraction, with *A* and *B*, and in reacting to sound with sound as a distraction with *C*, *D*, *E*, and *F*.

A and *B* received less training in reacting to light with sound or touch as a distraction. *C*, *D*, *E*, and *F* received the less training in reacting to sound with light or touch as a distraction. *A* and *B* received no training in reacting to sound with sound, light, or touch as a distraction. *C*, *D*, *E*, and *F* received no training in reaction to light with light, sound or touch as a distraction. All these subjects, however, had received more or less training with all the distractions, as these were the same throughout the experiment, no matter with which stimulus they were used.

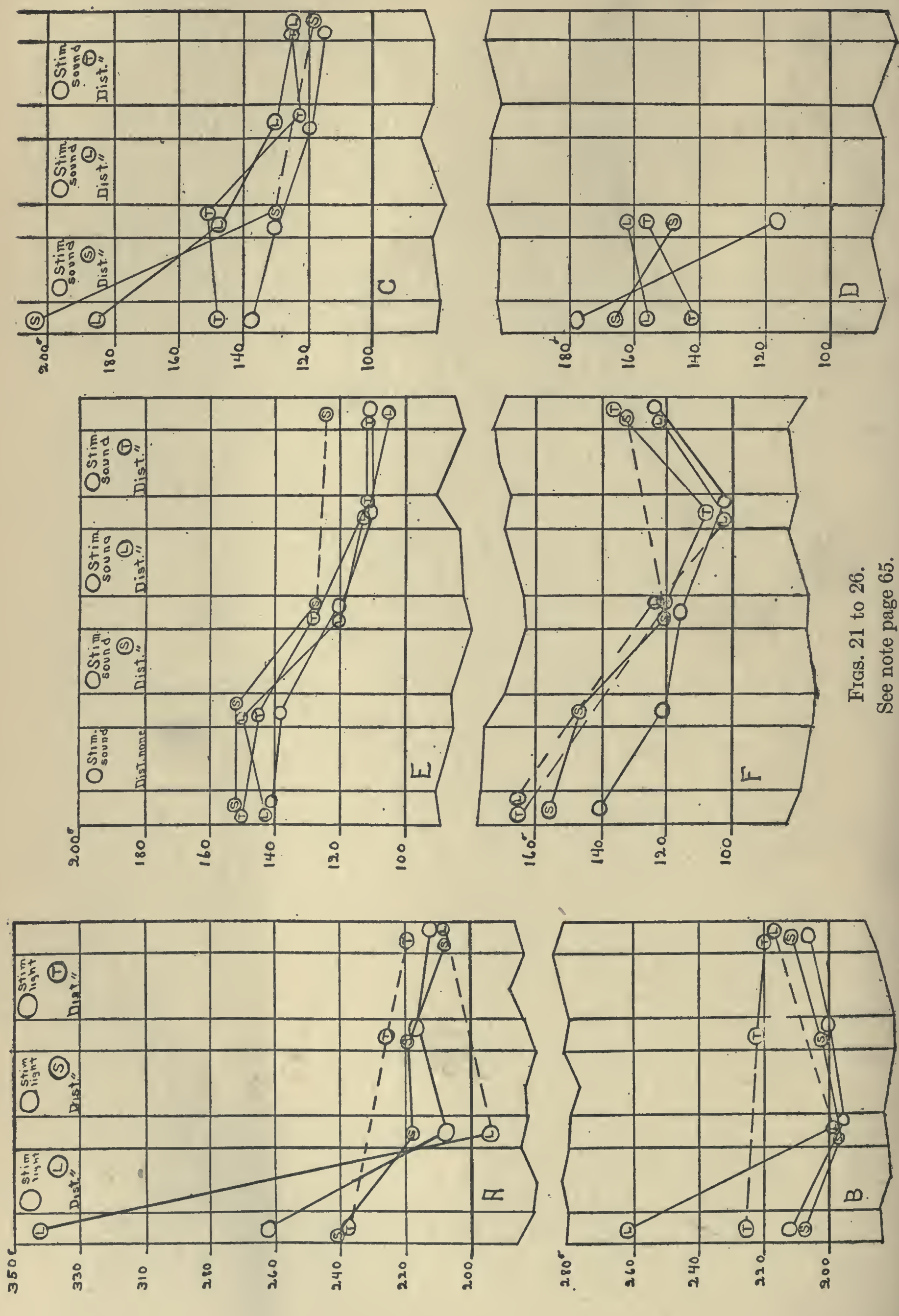
From the table it may be seen that *the ability gained by reacting to a particular stimulus with a particular distraction is a great aid to the subjects in reacting to a new stimulus with the same distraction, and in reacting to the same stimulus but with a different distraction.*

A priori, one would think that more transfer would be made in the last case, as the subject has become accustomed to the stimulus and has to accustom himself only to the distractions, whereas in the former case, he must accustom himself to the new stimulus while the distractions add their disturbance to the situation. Although the distractions were previously encountered when reacting in the training series the attention was always on the stimulus, and not on the distraction. Indeed, transfer was actually more prominent in accordance with these expectations, although the difference is slight, when compared with the difference between either one and the gain in the directly trained performance.

From the previous tables it is quite obvious that the special training has a decided influence on other performances than the performance in which the training occurred. Gain in the performance in which little training occurred was very noticeable. But even when no training was given in a performance the gain transferred from the special training was more than 35 per cent. of the gain in that training.

The transfer found here seems to be of two kinds. Ability gained in reacting to one stimulus aided in reacting to another stimulus. This was gain in the ability to do an act. But ability to ignore certain distractions was also transferred. This, however, was not gain in ability to do something but rather gain in ability not to do something, *i. e.*, not to be influenced by the distraction.

Tables LVII. to LIX. were obtained by taking the preliminary test, the first reactions and the last reactions in each practise series, and the final control test. While this comparison may not explain



FIGS. 21 to 26.
See note page 65.

why change occurs, it does indicate *where* change occurs. To illustrate: in the table for *A* and *B* the first reactions shown were made in the preliminary test. After training in reacting to light with light distraction the second series was obtained. The 209.8 σ is *A*'s reaction-time to light at the end of the practice period. The 195.0 σ in the second column is his reaction-time to light with light distraction, while 218.0 σ is the first reaction to the new series, the stimulus still being light but the distraction sound. The italicized figures give the probable errors of the average immediately above. The results can perhaps be more readily appreciated from their graphic representations in Figs. 21 to 26.

If the training effect of the work of the subjects was narrowly specific, the curve for each distraction should remain high till its own specific training had been given, then drop suddenly, then go up again to some degree after training with another distraction. If, on the contrary, the training effect was general (within the limits of the variations of the task here employed), all the curves should follow about the same course. Evidently the latter condition is approximately the fact. There is, in fact, no clear evidence of any extra benefit to a particular task from the special training in it. The gain occurs chiefly as the result of the first practice series with any distraction. It looks as it even the brief practise afforded by the preliminary tests was sufficient to give considerable adjustment to the distraction, for the distraction that came first in the preliminary series usually shows the most difference from the simple reaction. (Cf. Tables XXXII. to XXXVII.)

VIII. PRACTISE WITH A GIVEN DISTRACTION SHORTENS THE PERIOD OF ADAPTATION TO A NEW DISTRACTION

Another element in improvement due to previous training is the rapidity of the improvement, the rapidity with which a subject adapts himself to the new conditions. This has never been properly credited in the scheme of transfer. Under new conditions the subject shows more ability in the beginning than he showed in

FIGS. 21–26.

The narrow vertical strips represent the successive cross-sections of the subjects' abilities, as given in Tables LVII to LIX, and the broader strips represent the practise periods. The small circles without letters represent the simple reaction ability at each cross-section period; those circles with *L* inside give the reaction ability with light distraction, those with *S* with sound distraction, and those with *T* with touch distraction. The larger circles at the top of the broad strips symbolize the kind of training that occurred in each practice series. The letters in the upper circles indicate the distraction used, while the letter in the lower circle indicates the stimulus used.

previous control test. In the course of the new work he tends to adjust himself more easily or to recover very quickly.

We may notice some concrete examples of these points.

Subject *B* in the beginning made a reaction of 212.8 σ to light, and 260.3 σ, to light with light distraction. The latter is soon reduced to 203.9 σ and the simple reaction time to 191.3 σ. These represent about the physiological limit of the subject, who had had considerable training previously. Evidently, any further improvement will be represented by small differences. Now when the distraction was changed to sound the pure reaction time was 195.0 σ, and the time with distraction was 196.5 σ with a variation of 10.5 σ. The initial performance in the preliminary control test to light with sound distraction had been 208.9 σ.

In the preliminary test when touch distraction was present the time was 225.9 σ, M.V. 8.1 σ. This time was reduced to 222.6 σ after training with light and sound distractions, and further reduced by special training to 219.9 σ, M.V. 14.7 σ.

Reference to the table will show the effect of the training upon the other activities of subject *B*. With the exception of sound there is a gain in reaction ability. The graphic representations show this quick drop in the curve due to quick adaptation to the new conditions.

Subject *A* was untrained, and his preliminary records were very high, especially those with light, and light with light distraction. Considerable gain must be expected here. In the preliminary test the time of reacting to light with sound distraction was 241.9 σ; while after practise with light distraction the new series with sound distraction began with 222.2 σ. The shortest reaction-time in this series was 207.1 σ. If we use this as a basis of comparison, then the previous training brought an improvement in the unpractised performance of 70 per cent.[4] With the touch distraction a similar gain of 45 per cent. was noticed. We may also observe that the limit of improvement is here reached after four hundred reactions, while 1,000 were required to reach the limit in the first practise series. Thus, the period of adjustment is reduced more than one half by the previous training in reacting with the other distractions.

Table LX. gives a summary of the gain due to specific and to non-specific training. The figures under "Gain by Practise" give the gain within a series due to the specific practise of that series; they show the difference between the first reaction in the series and the quickest reaction made in that series. The "Entire Gain" is the difference between the quickest reaction in the series and the reaction made in the preliminary test. Subtracting the "Gain by Practise" from the "Entire Gain," we have the gain *not* due to specific practise, but appearing at the outset of such practise as the result of previous practise with other distractions. This transferred gain, expressed as a per cent. of the "Entire Gain," appears in the last column.

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[4] Since he reduced his time to but 207.1σ it is safe to say that in the beginning his range for improvement then was from 241.9σ down to 207.1σ, or a range of 34.8σ, but 19.7σ, or approximately 70 per cent. of this reduction occurs before the time of practise in the performance.

TABLE LX

Subject.	*Performance* *Stim.*	 *Dist.*	*Gain by Prac.*	*Entire Gain.*	*% of Gain before Prac. in the Perform.*
A	Light	Light	148.6σ	148.6σ	
	“	Sound	10.9	34.8	70
	“	Touch	15.9	29.2	45
B	Light	Light	63.6	63.4	
	“	Sound	4.0(?)[5]	12.4	69
	“	Touch	14.6	17.9	19
C	Sound	Sound	86.2	86.2	
	“	Light	22.4	60.8	64
	“	Touch	5.8(?)	21.8	74
D	Sound	Sound	35.7	35.7	
E	Sound	Sound	32.6	32.1	
	“	Light	13.8	37.4	64
	“	Touch	2.5	41.1	92
F	Sound	Sound	39.4	48.6	
	“	Light	10.1	65.5	85
	“	Touch	7.0(?)	58.3	88
					Gen. Av. 66.9%

TABLE LXI

Subj.	*Dist.*	*Sittings*	*Subj.*	*Dist.*	*Sittings*
A	Light	8	*B*	Light	2
	Sound	2		Sound	0
	Touch	1		Touch	1
C	Sound	9	*D*	Sound	6
	Light	4			
	Touch	0			
E	Sound	8	*F*	Sound	3
	Light	4		Light	0
	Touch	0		Touch	0

It is safe to conclude that reacting to a stimulus with a distraction gives aid in reacting to the same stimulus when a different distraction is used.

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[5] The differences followed by a question mark are probably not characteristic, as the subjects showed much greater gain at other periods. The control reaction from which the difference was obtained was probably too high to represent the subject's ability.

Table LXI. indicates the approximate number of sittings necessary before adaptation to each new distraction was so well established that no further rapid improvement occurred.

The two tables indicate that the ability gained by special training influenced the following reactions under changed conditions of distraction. This was anticipated as the same motor path was functioning in all the reactions. The resistance of this path had been lowered by the first period of training. The introduction of each new distraction was accompanied by some resistance, as any distraction tends to produce some motor response, which may have been originally protective. Thus, a sound causes one to "start" or turn toward the source of the sound. Whether the energy will be directed into this original path or into the path established by practise will depend on how much training has been given. The subjects made this adjustment quickly.

This is closely analogous to the state of attention. As the resistance in the pathway decreased the attention became more effective, the objective influences more automatically controlled. To disturb this pathway or increase the resistance, or divert the attention, some change must occur in the objective influences, *e. g.*, the distraction might be made more intense.

This is a physiological condition and is not to be confused with the mystical influence so often introduced in formal discipline.

IX. CHANGE IN THE VARIABILITY OF THE REACTION TIME DUE TO PRACTISE

The figures in Table LXII. show the average of the M.V.'s under the influence of the different distractions used. Practise with the several distractions occurred in the order shown for each subject in the table.

TABLE LXII

		Distractions		
Subject	*Stim.*	*Light*	*Sound*	*Touch*
A	Light	12.7σ	7.4σ	8.2σ
B.[24]	"	6.8	8.5	8.1
Gen. Av.		**9.8**	**7.9**	**8.1**
		Sound	*Light*	*Touch*
C	Sound	10.0σ	5.7σ	5.4σ
D	"	9.7		
E	"	8.2	5.9	4.1
F	"	6.4	4.4	3.5
Gen. Av.		**8.5**	**5.3**	**4.3**

[24] As *B* was the most practised subject at the beginning of the experiment more uniformity would be expected in his reactions, which seems to be the case.

The effect of practise on the variability does not seem uniform. There is a uniform decrease with subjects *C*, *E*, and *F*, which is not so noticeable with *A* and *B*. The general averages indicate, however, that practise does decrease the variability, and that this effect is carried over from practise with one distraction to practise with another.

The effect of practise on the variability may also be noticed by reference to Table LXIII. In this case we have the relative variability. This relative variability represents the average of a series of Pearson Coefficients, *i. e.*, the general average of the variabilities found by dividing the gross variability of a group by its corresponding reaction time (*i. e.*, the Σ Pearson Coefficients/*n*).

TABLE LXIII

Rel. Var. with no Dist.[6]				*With Dist.*		
Subj.	*Stim.*		*Aver.*	*Dist.*		*Aver.*
A	Light	.045		Light	.057	
	"	.037		Sound	.034	
	"	.032		Touch	.037	
			.038			.043
B	Light	.030		Light	.032	
	"	.029		Sound	.043	
	"	.048		Touch	.037	
			.036			.037
C	Sound	.043		Sound	.071	
	"	.033		Light	.042	
	"	.035		Touch	.047	
			.037			.053
D	Sound	.046		Sound	.065	
E	Sound	.047				
	"	.045		Sound	.057	
	"	.034		Light	.052	
	"	.031		Touch	.036	
			.040			.049
F	Sound	.039				
	"	.034		Sound	.052	
	"	.047		Light	.039	
	"	.035		Touch	.030	
			.039			.040
Gen. Av.		..038			.045	

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[6] Thorndike has suggested that the gross variability divided by the square root of the average would be in accord more with both theory and facts. But to treat our series in this manner would not change the data enough to influence our conclusion. For example, if the average of the sum of Pearson Coefficients is used the figures of variability are .033 and .042 for sound, and sound distraction, respectively, for *C*. If the Thorndike Coefficient is used the figures are .372 and .392 for the same series. Thorndike, "Mental and Social Measurements," p. 133, 1913.

There was a more uniform decrease when distraction was present than when it was not present. In the case of *E* and *F* there is a definite and uniform decrease with distraction present, but this uniformity is not so noticeable in their reactions without distraction.

This table also shows whether a subject is more variable in reacting with or without distraction. The first column in the table represents the variability of the series when no distraction was used. The second series indicates the variability when distraction was used.

Although the difference is small, in most cases the subjects are more variable in their reacting when the distraction was present. There are four exceptions. If only the general average of the variability for each subject both with and without distraction is noted, then every subject is more variable when the distraction was present than when it was not used. There is, accordingly, a tendency, to be more variable when distraction is present, but this tendency is decreased by practise.

X. SUMMARY OF CONCLUSIONS

1. The ability gained by prolonged practise in simple reaction to one stimulus seems to be transferred bodily when reactions are made to another stimulus (p. 58).

2. A very definite gain was made when reactions were made to a stimulus different from the one used in practise but with the same distractions (p. 59).

3. Training in reacting to a stimulus without distraction has very little effect on reacting to the same stimulus with a distraction, except, possibly to cause a slight reduction in variability.

4. Practise in reacting to a particular stimulus with a particular distraction aids in reacting to a new stimulus with the same distraction, or to the same stimulus but with different distractions.

5. Practise has a tendency to decrease the variability of reaction time. Practise reduces the period of adaptation to other reaction performances.

6. *Training of Attention.*—To attend well means ability to ignore non-essentials for the sake of the essentials. The essentials have been brought to the front by the development of certain valuable habits. The development of these habits has been in opposition to the influences of distraction. The subject has acquired certain adjustments to the constant conditions of his work. Useless reactions have been repressed early in the practice period. With this ability to ignore the non-essential stimuli comes a certain feeling of self-confidence and self-reliance which stimulates the

subject to active interest in the work. It is this attitude or adjustment which makes transfer possible. We could expect little or no transfer effect to result from practise if an attitude or "set" or neural adjustment which had been previously acquired could not be used in the new situation.

This experiment well illustrates the above conditions. In developing the power of ignoring the distracting influences, attention was, in effect, developed. The ability to ignore the unessential and to subordinate the minor to the major elements of the situation is synonymous with good attention. The more chances afforded to develop these good habits of attention, the more possibility there will be for transfer to occur.

TABLES OF RESULTS

TABLE I

Subject A *Reaction Without Distraction*				*Stimulus Light*		*Distraction Light* *Reaction With Distraction*		
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Nov. 17	261.4	20.5	5.1	343.3	13.2	3.4	1.31	
23	213.1	16.1	9.5	323.8	42.7	10.2	1.52	
25	222.6	28.1	21.6	303.4	23.3	6.5	1.36	
26	268.0	22.2	13.1	274.2	27.1	7.0	1.02	
29	278.8	29.1	17.1	269.3	18.5	4.8	.96	
30	238.8	2.4	1.4	270.7	16.4	4.2	1.13	1.23
Dec. 1	295.6	28.8	13.8	263.9	17.1	4.5	.89	
6	232.7	1.0	0.6	212.3	8.5	2.1	.91	
8	212.3	9.8	5.8	209.0	21.6	5.4	.98	
9	208.8	20.7	12.2	221.5	14.4	3.5	1.06	
12	184.9	6.3	3.7	209.7	9.5	2.5	1.13	.99
13	218.5	7.9	3.0	220.6	11.6	2.9	1.00	
19	224.0	9.0	3.3					
26	194.5	3.4	1.6	212.6	7.5	2.0	1.09	
				229.1	18.8	4.5	1.17	
29	209.8	6.5	3.1	210.3	8.0	2.1	1.00	
29	197.9	3.3	1.6	202.5	14.7	3.7	1.02	1.08
30	202.3	5.1	2.4	206.6	6.1	1.6	1.02	
31	208.0	39.8	19.1	206.5	7.7	2.0	.97	
31	213.6	5.6	2.9	218.1	10.1	2.6	1.02	
31	224.2	6.4	3.1	222.1	6.5	1.7	.99	
31	206.5	15.8	9.2	219.0	6.7	1.7	1.06	1.00
Jan. 1	201.6	8.3	4.0	215.3	9.2	2.4	1.06	
1	202.2	6.4	3.1	210.7	6.3	1.6	1.04	
2	226.5	10.7	3.9	243.3	12.6	3.3	1.07	
3	209.5	7.8	2.9	212.4	10.4	2.7	1.01	
5	222.4	6.5	2.4	221.7	6.9	1.8	.99	1.05
6	216.5	4.2	1.5	206.8	17.9	4.5	.95	
10	213.6	7.5	2.8	217.7	6.9	1.7	1.01	
13	215.8	13.1	6.3	201.0	15.0	3.9	.93	
				214.4	7.6	2.1	.99	
16	214.4	7.9	3.4	204.4	12.0	3.0	.95	.97
22	208.7	1.1	3.5	194.7	6.3	1.6	.93	
				198.7	12.3	3.0	.95	
Feb. 4	205.5	7.8	2.5	193.1	9.1	2.4	.93	
				202.7	11.0	2.7	.98	
7	232.8*	5.6	2.1	211.5	5.2	1.3	.90	.95
				205.6	13.0	3.4	.88	
10	218.4	9.0	3.3	203.9	8.9	2.2	.93	
13	209.8	4.0	1.5	195.0	11.4	2.8	.93	
								.91
Av.	222.7	11.1		225.2	12.7			

Relative variability............ .045 Relative variability...... .057

* The subject stated, after these reactions were taken, that he had just previously suffered from toothache, but had allayed the pain with drugs. Evidently the effect of the drugs was still present when the reactions were made. It seemed that this influence was partially overcome by forced attention when distraction was introduced.

TABLE II

Subject B *Stimulus, Light* *Distraction, Light*

Reaction Without Distraction *Reaction With Distraction*

Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Dec. 10	212.8	3.9	1.9	260.3	13.9	3.5	1.22	
13	200.1	18.2	8.7	220.1	10.2	2.7	1.09	
Feb. 17	193.2	4.0	1.0	203.9	5.7	1.5	1.05	
				209.2	4.8	1.2	1.08	
18	191.3	2.5	0.9	206.3	6.3	1.6	1.07	
				212.3	5.6	1.4	1.10	1.12
20	199.6	4.3	2.0	207.6	3.8	0.9	1.04	
21	199.4	7.7	2.8*	214.8	5.3	1.4	1.07	
				210.1	12.3	4.4	1.05	
				215.3	4.6	1.2	1.07	
				215.2	6.7	1.7	1.07	1.07
22	188.7	5.0	1.8	196.9	6.4	1.6	1.05	
				205.4	8.4	2.2	1.08	
				208.9	4.8	1.2	1.10	
25	201.3	3.6	1.3	196.7	4.7	1.2	.97	
				191.2	6.8	1.7	.94	1.05
28	198.7	5.9	2.2	198.3	7.5	1.9	.99	
				214.8	5.6	1.4	1.08	
Mar. 7	195.0	4.7	1.7	199.4	6.0	1.5	1.02	
								1.01
Av.	198.0	6.0		209.8	6.8			
Relative variability			.030	Relative variability				.032

TABLE III

Subject A *Stimulus, Light* *Distraction, Sound*

Reaction Without Distraction *Reaction With Distraction*

Date.	*Time.*	*M.V.*	*P.E.*	*Time.*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Feb. 16	211.9	10.3	3.8	218.0	6.8	1.7	1.02	
17	205.2	6.2	2.3	222.2	4.3	1.1	1.08	
20	251.5	6.8	2.5	207.7	6.4	1.7	1.53	
23	213.3	8.1	3.0	214.3	8.1	1.1	1.00	
				208.4	7.7	2.1	.97	
24	206.4	4.2	1.5	210.5	8.3	2.2	1.01	1.02
				210.3	6.0	1.5	1.01	
Mar. 7	205.8	11.0	4.1	207.1	8.0	2.1	1.55	
14	217.2	8.7	3.2	233.2	8.0	2.1	1.07	
				218.8	7.7	1.9	1.00	
								1.02
Av.	209.3	7.6		214.9	7.4			
Relative variability			.037	Relative variability				.034

* Series taken throughout the day.

TABLE IV

Subject B *Stimulus, Light* *Distraction, Sound*

	Reaction Without Distraction			*Reaction With Distraction*				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Mar. 7	195.0	4.7	1.7	196.5	10.5	2.6	1.01	
10	204.8	4.9	2.0	200.5	7.8	2.0	.97	
				211.9	4.2	1.1	1.03	
15	203.2[1]	9.9	3.6	198.3	8.0	1.9	.97	
17	227.8	5.3	1.9	224.8	14.5	3.7	.98	
18	210.0	8.0	0.4	199.2	7.4	2.5	.94	.99
24	200.9	5.2	1.9	201.6	6.6	1.7	1.00	
				210.4	8.6	2.2	1.04	
								.99
Av.	206.9	6.3		205.4	8.5			
Relative variability			.029	Relative variability				.043

TABLE V

Subject A *Stimulus, Light* *Distraction, Touch*

	Reaction Without Distraction			*Reaction With Distraction*				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Mar. 19	221.6	10.8	4.0	224.7	6.3	1.6	1.05	
20	197.4	7.6	2.8	207.7	7.1	1.8	1.10	
				223.9	11.1	2.6	1.11	
				219.4	7.8	2.0	1.11	
				220.8	8.5	2.1	1.04	
21	202.7	3.2	1.2	212.6	7.7	1.9	1.03	1.08
				208.8	10.6	2.6	1.02	
				218.5	6.1	1.4	1.03	
25	213.3	5.7	1.9	221.8	8.9	3.3	1.08	
								1.04
Av.	208.7	6.8		217.6	8.2			
Relative variability			.032	Relative variability				.037

TABLE VI

Subject B *Stimulus, Light* *Distraction, Touch*

	Reaction Without Distraction			*Reaction With Distraction*				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Mar. 19	202.3	10.4	3.8	222.6	6.1	1.6	1.10	
30	210.2	4.3	1.6	211.6	5.3	1.4	1.00	
				216.5	10.3	2.7	1.03	
				212.4	10.1	2.6	1.01	
				214.6	8.7	2.2	1.02	
31	207.3	15.3	5.6	220.2	10.6	2.7	1.06	1.03
				208.0	5.6	1.4	1.00	
Av.	206.6	10.0		215.1	8.1			
Relative variability			.048	Relative variability				.037

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[1] Becomes 198.0 if the first average (224.1, M.V. 20.9) of the first set is omitted.

TABLE VII

Subject C *Stimulus, Sound* *Distraction, Sound*

Reaction Without Distraction				*Reaction With Distraction*				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Nov. 14	139.0	7.6	1.9	206.0	19.7	4.7	1.48	
15				218.9	7.6	2.0	1.57	
18				202.3	22.2	5.1	1.45	
19				199.4	23.5	5.9	1.43	
20				149.2	9.4	2.2	1.07	
21				151.2	18.7	4.5	1.08	1.40
				158.2	22.3	5.5	1.13	
24	143.3	4.4	2.1	160.3	20.0	5.2	1.11	
25	150.0	9.1	5.3	142.5	9.7	2.4	.95	
26	110.0	5.7	3.3	133.1	8.7	2.2	1.21	
29	119.6	5.7	3.3	143.7	15.5	4.0	1.20	1.09
Dec. 1	116.1	9.6	5.6	144.6	7.4	1.9	1.24	
6	119.1	1.9	1.1	159.9	11.2	2.9	1.34	
8	109.3	5.5	3.2	137.8	13.3	3.4	1.26	
9	113.1	0.2	0.1	143.2	10.6	2.7	1.26	
12	133.8	4.4	2.6	148.4	19.2	4.8	1.10	1.26
13	128.8	12.6	6.0	150.1	13.1	3.3	1.17	
Jan. 1	106.1	7.3	3.5	119.8	4.9	4.4	1.12	
				136.3	7.0	1.8	1.28	
10	114.7	1.2	0.6	133.5	9.5	2.5	1.16	
19	123.2	4.4	1.6	137.4	7.4	1.9	1.11	1.17
22	120.7	7.0	2.6	152.6	21.1	5.5	1.26	
23	130.4	4.6	2.2	133.2	7.4	1.9	1.02	
				128.1	7.3	1.9	.98	
Feb. 9*	125.9	5.6	2.0	145.0	7.4	2.5	1.15	
				150.9	6.6	1.6	1.11	1.10
				144.5	10.2	2.6	1.14	
				139.1	6.1	1.6	1.10	
10	130.1	6.4	2.3	149.1	7.0	1.8	1.14	
				132.9	6.2	1.6	1.02	
12	117.6	3.8	1.4	129.3	5.6	1.4	1.09	1.10
13	125.3	5.4	2.0	134.7	9.2	2.4	1.07	
				137.4	6.2	2.5	1.08	
17	116.1	2.8	1.0	129.2	6.0	1.4	1.11	
18	122.6	2.9	1.4	136.0	6.6	1.4	1.12	
19	122.9	2.8	1.0	137.6	5.1	1.3	1.12	1.09
20	130.9	5.2	1.7	131.8	8.5	2.2	1.00	
								1.06
Av.	123.7	5.3		140.2	10.0			
Relative variability			.043	Relative variability				.071

* The first two records for Feb. 9 were made at 1 P.M.; the last two at 3 P.M.

TABLE VIII

Subject C *Stimulus, Sound* *Distraction, Light*

Reaction Without Distraction				*Reaction With Distraction*				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Feb. 20......	130.9	5.2	1.7	148.2	9.5	2.5	1.13	
24......	121.6	4.8	1.8	144.3	7.9	2.1	1.18	
				143.3	1.0	1.5	1.17	
25......	114.3	1.0	0.5	125.8	6.6	1.7	1.10	
27......	125.8	9.3	3.4	134.9	5.1	1.3	1.07	
Mar. 3......	115.8	2.4	0.9	127.0	5.0	1.3	1.09	1.03
				126.4	4.4	1.2	1.09	
9......	119.6	2.1	1.2	130.9	4.7	1.2	1.09	
				130.0	7.5	1.9	1.08	
								1.09
Av...........	121.3	4.1		134.5	5.7			
Relative variability..........			.033	Relative variability............				.042

TABLE IX

Subject C *Stimulus, Sound* *Distraction, Touch*

Reaction Without Distraction				*Reaction With Distraction*				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Mar. 2......	110.4	3.1	1.1	121.8	5.5	1.5	1.10	
16......	121.6	1.9	0.7	127.6	6.4	1.6	1.04	
				124.2	4.5	1.2	1.02	
20......	117.8	7.3	2.7	132.4	5.3	1.3	1.12	
24......	116.8	2.5	2.3	127.0	4.7	1.2	1.08	
24......	116.2	6.3	0.9	121.8	5.9	1.5	1.04	1.09
28......	115.2	3.9	1.4	125.0	5.7	2.1	1.08	
								1.06
Av...........	116.2	4.2		125.7	5.4			
Relative variability..........			.035	Relative variability............				.047

TABLE X

Subject D *Stimulus, Sound* *Distraction, Sound*

	Reaction Without Distraction			*Reaction With Distraction*				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Nov. 28	134.4	8.1	4.8	166.7	17.3	4.5	1.24	
Dec. 8	124.7	6.2	3.6	153.8	10.0	2.6	1.23	
11	125.1	6.2	2.6	154.5	12.9	3.3	1.23	
12	136.9	2.2	1.3	143.4	12.8	3.6	1.05	
Jan. 3	124.4	4.6	2.2	161.3	11.4	2.3	1.29	
6	123.6	8.4	3.1	142.8	11.0	2.9	1.15	1.21
				141.7	6.6	1.7	1.14	
23	133.2	6.3	2.3	135.8	6.1	1.6	1.02	
				142.6	12.7	3.3	1.07	
				131.0	7.7	2.0	.98	
				138.9	7.3	1.9	1.04	1.07
Feb. 5	128.1	3.4	1.2	151.6	8.2	2.1	1.23	
				136.8	8.0	2.1	1.06	
				140.3	4.2	1.1	1.09	
				149.3	9.1	2.3	1.16	
				133.2	9.0	2.1	1.04	1.12
12	117.3	2.8	1.0	149.8	11.0	4.1	1.27	
Av.	127.5	5.4		147.1	9.7			
Relative variability			.046	Relative variability				.065

TABLE XI

Part A
Stimulus, Sound
Subject E

Date	*Time*	*M.V.*	*P.E.*
Dec. 12	141.5	7.4	2.5
Feb. 5	123.6	14.6	5.4
10	136.6	9.8	2.5
	143.1	5.3	1.3
12	135.7	8.9	2.3
	127.4	4.8	1.0
	125.1	3.0	0.7
14	131.9	6.4	1.6
	131.1	5.8	1.5
	133.2	4.7	1.2
16	137.0	8.7	2.2
	126.3	2.4	0.6
17	130.2	6.8	1.7
	126.5	10.9	2.6
24	139.0	9.0	3.3
Av.	132.5	7.2	
Relative variability			.047

Part B
Distraction, None
Subject F

Date	*Time*	*M.V.*	*P.E.*
Jan. 22	140.0	3.1	1.1
Feb. 12	137.0	2.9	0.7
	137.7	4.6	1.2
	148.0	5.7	1.3
	144.8	7.1	1.8
13	135.6	7.4	1.7
	132.5	4.0	1.0
	139.9	6.6	1.7
	137.4	6.8	1.6
14	125.5	4.6	1.2
	119.5	5.4	1.4
	110.4	5.2	1.3
16	127.8	4.7	1.1
	124.8	4.3	1.3
21	148.6	10.7	2.8
	127.1	6.3	1.6
	118.4	4.5	1.2
25	Omitted		
27	Omitted		
Mar. 9	121.2	1.6	0.6
12	122.9	5.7	1.5
	120.3	3.4	0.9
Av.	130.0	5.2	
Relative variability			.039

TABLE XII

Subject E *Stimulus, Sound* *Distraction, Sound*

Reaction Without Distraction				*Reaction With Distraction*				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Feb. 24	139.0	9.0	3.3	153.7	10.3	2.7	1.10	
28		Omitted			Omitted			
		"			"			
		"			"			
Mar. 2	128.3	5.2	1.9	150.8	5.5	1.5	1.17	
				156.8	7.5	2.0	1.22	
6	126.9	4.3	1.6	151.7	23.5	3.0	1.19	
				161.1	6.8	1.7	1.26	
7	124.0	7.9	2.9	137.6	9.5	2.5	1.10	1.19
9	128.2	5.9	2.0	130.1	4.9	1.3	1.01	
				123.1	3.9	1.0	.96	
10	119.6	4.1	1.5	133.8	4.1	1.3	1.11	
				130.6	3.1	0.8	1.09	
12	120.6	7.0	2.4	126.0	6.1	1.6	1.00	1.05
15	107.5	3.1	1.1	121.1	4.7	1.2	1.12	
								1.06
Av.	124.2	5.8		138.4	8.2			
Relative variability			.045	Relative variability				.057

TABLE XIII

Subject F *Stimulus, Sound* *Distraction, Sound*

Reaction Without Distraction				*Reaction With Distraction*				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Mar. 9	121.2	1.6	0.6	147.4	14.5	3.6	1.21	
12	113.1	4.2	1.5	125.6	6.8	1.7	1.11	
15	111.0	2.7	1.0	118.8	2.8	0.7	1.07	
17	115.5	2.7	1.0	118.5	5.5	1.4	1.02	
				124.9	6.9	1.7	1.08	
17	115.1	3.7	1.3	120.3	6.5	1.6	1.04	1.10
18	117.5	6.6	2.4	120.4	3.0	0.8	1.02	
				119.2	8.2	2.1	1.01	
19	113.5	5.5	2.0	108.0	3.2	0.8	.95	
				117.1	6.5	1.6	1.03	
								1.01
Av.	115.3	3.9		122.0	6.4			
Relative variability			.034	Relative variability				.052

TABLE XIV

Subject E *Stimulus, Sound* *Distraction, Light*

Reaction Without Distraction				*Reaction With Distraction*				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Mar. 17	118.6	3.5	1.3	119.5	7.5	1.9	1.00	
	115.5	9.6	3.5	115.4	5.7	1.4	.98	
				120.5	4.3	1.1	1.04	
19	114.0	3.4	1.2	114.3	7.5	1.9	1.00	
				115.8	6.5	1.6	1.01	
20	110.2	0.6	0.2	116.8	3.1	0.8	1.06	1.01
				114.3	5.2	1.3	1.03	
				110.8	3.4	0.8	1.00	
21	111.1	4.0	1.5	113.9	3.1	0.8	1.02	
				108.5	2.6	0.7	.97	
21				119.1	5.7	1.1	1.07	1.02
				110.9	4.5	1.2	.99	
				107.1	5.0	1.2	.96	
22	111.4	3.3	1.1	105.7	18.5	6.3	.95	
								.99
Av.	113.4	4.1		113.7	5.9			
Relative variability			.035	Relative variability				.052

TABLE XV

Subject F *Stimulus, Sound* *Distraction, Light*

	Reaction Without Distraction			Reaction With Distraction				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Mar. 20	112.6	5.5	2.0	111.7	2.3	0.6	.99	
				113.0	5.2	1.3	1.00	
24	121.4	5.9	2.0	116.1	3.7	1.0	.96	
				117.4	6.6	1.6	.96	
24	107.5	3.8	1.4	109.9	5.5	1.4	1.02	
				109.5	4.1	1.0	1.02	.99
25	104.3	6.0	2.2	101.6	3.8	0.9	.97	
								.99
Av.	111.5	5.3		111.3	4.4			
Relative variability			.047	Relative variability				.039

TABLE XVI

Subject E *Stimulus, Sound* *Distraction, Touch*

	Reaction Without Distraction			Reaction With Distraction				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R.*
Mar. 21	106.3	3.6	1.3	111.0	5.2	1.3	1.04	
				111.3	5.5	1.3	1.04	
				111.4	3.3	1.1	1.04	
Mar. 22	111.4	3.3	1.1	118.9	3.3	0.8	1.06	
				113.8	5.6	1.4	1.02	
" 22				111.3	6.2	1.6	.99	1.04
				108.5	2.6	0.7	.97	
" 22				109.6	2.8	0.7	.98	
				109.9	2.8	0.7	.98	
								.98
Av.	109.7	3.0		111.7	4.1			
Relative variability			.031	Relative variability				.036

TABLE XVII

Subject F *Stimulus, Sound* *Distraction, Touch*

	Reaction Without Distraction			Reaction With Distraction				
Date	*Time*	*M.V.*	*P.E.*	*Time*	*M.V.*	*P.E.*	*R.*	*Av. of R*
Mar. 25	Omitted			Omitted				
26	112.2	2.4	0.9	108.1	3.2	0.8	.96	
	115.1	3.1	1.1	115.5	2.6	0.7	1.00	
				112.8	3.6	0.8	.98	
27	112.1	3.8	1.0	108.5	2.6	0.7	.96	
				112.2	4.1	1.0	1.00	
				114.7	3.0	0.8	1.02	.98
Apr. 1	123.9	8.3	3.1	135.0	5.7	1.5	1.08	
								1.05
Av.	115.8	4.4		115.2	3.5			.030
Relative variability			.035	Relative variability				

Daily Work of C.

Simple Reaction-time					Reaction-time with Distraction.										
146.0	132.7	144.9	137.4	135.7	235.4	238.6	215.9	213.0	185.1	187.8	194.8	178.4	216.8	202.4	
					226.4	239.5	221.5	215.5	226.5	219.3	204.0	212.8	207.0	217.4	
					213.1	180.7	191.3	181.7	226.1	191.2	224.9	216.1	194.5	202.7	
					184.7	179.3	172.0	178.8	176.2	228.6	177.8	200.2	146.8	157.6	
					170.4	145.1	159.2	134.3	137.7	140.9	141.5	149.8	157.9	156.0	
					172.2	158.4	100.4	141.6	163.0	150.4	112.4	161.2	140.0	171.6	
					202.4	152.8	103.9	215.9	169.0	168.2	139.8	149.1	148.2	145.4	
143.1	161.1	135.9			199.6	157.3	146.6	170.3	177.0	148.0	129.2	144.7	135.7	194.6	
193.9	159.1	141.0			119.7	151.2	153.7	144.0	148.0	138.7	134.6	134.2	142.8	150.6	
115.8	104.3				133.2	126.3	140.9	142.9	143.5	116.7	133.6	118.8	143.4	132.1	
113.9	125.4				127.1	121.0	135.7	204.8	143.7	156.6	136.0	136.5	147.2	128.3	
125.7	106.5				133.0	127.0	151.0	154.0	149.0	144.9	159.5	140.4	141.1	146.8	
121.0	117.2				152.5	149.4	170.3	163.2	151.4	158.5	131.6	166.7	190.6	165.0	
114.8	103.8				152.5	150.1	117.1	133.3	135.7	134.2	116.1	124.0	159.9	155.5	
113.0	113.3				135.1	149.8	140.8	151.2	176.7	136.2	148.3	120.8	130.2	143.3	
129.4	138.2				140.2	135.7	127.1	138.2	166.1	134.0	191.2	133.4	193.9	136.6	
132.1	109.8	144.5			128.8	161.9	151.6	165.1	134.2	116.2	163.8	152.7	153.0	162.3	
109.3	95.1	113.8			119.9	122.1	110.1	115.9	127.3	116.8	114.3	131.7	119.9		
					139.4	121.7	129.4	136.3	147.3	122.7	145.9	139.5	138.9	141.9	
114.1	113.6	116.5			113.3	125.1	121.5	132.8	146.4	128.8	133.7	160.2	132.1	141.3	
124.3	118.7	130.7	125.6	116.6	111.5	136.2	133.7	137.5	158.5	131.5	146.1	137.2	142.9	139.5	
111.9	123.4	112.0	128.2	128.1	171.7	143.5	126.0	130.6	210.7	108.5	144.6	161.9	150.2	165.5	
126.2	137.4	127.7			125.2	145.0	136.5	123.5	122.1	144.6	140.8	136.2	127.4	130.8	
					127.7	125.0	137.5	126.8	101.8	135.4	122.5	142.7	128.5	133.6	
112.5	130.2	125.2	129.0	132.6	129.7	139.0	144.5	158.3	147.6	151.6					
					143.4	154.6	163.8	154.5	151.6	149.9	158.0	139.2	143.2	150.8	
					139.6	145.2	116.8	128.5	151.4	164.1	148.8	157.0	141.9	152.0	
					131.0	142.4	139.4	130.3	137.0	144.8	154.2	129.6	145.7	136.2	
118.4	131.5	125.8	130.3	144.4	141.5	140.5	133.9	150.5	148.9	149.8	146.2	164.3	157.4	157.3	
					136.3	127.5	128.8	141.7	135.7	136.5	143.5	125.5	118.9	135.1	
116.8	123.0	116.3	110.4	121.7	130.9	123.7	123.2	128.5	128.3	146.0	123.4	119.7	139.8	129.2	
111.6	127.5	126.8	128.9	131.5	163.5	135.3	125.9	131.8	128.6	129.6	127.0	119.6	146.8	139.5	
					129.2	123.5	131.3	151.5	145.7	142.1	158.8	150.2	125.7	126.8	
110.5	116.0	122.9	116.2	114.9	131.5	119.9	130.9	132.1	144.6	132.0	135.3	130.4	130.8	126.6	
124.1	127.7	123.1	122.7	115.4	119.1	126.1	155.4	136.2	140.3	137.5	140.3	131.4	134.3	139.5	
124.7	117.5	125.0	122.9	123.9	135.4	131.0	124.8	131.2	140.6	150.4	140.2	140.1	137.7	141.3	
138.1	134.9	131.9	127.4	126.8	125.6	125.3	124.6	125.0	140.5	118.7	128.8	145.3	140.7	143.6	
124.6	123.8	127.3	125.1	126.5	155.3	145.3	141.5	157.4	168.5	146.3	147.0	142.8	148.6	151.4	
138.1	134.9	131.9	127.4	126.8	171.1	151.1	145.7	142.7	136.2	138.5	143.2	144.2	142.9	128.5	
125.9	122.8	115.5	125.6	115.0	143.5	133.3	134.4	154.1	145.7	132.2	143.7	148.6	143.9	153.6	
					143.5	127.8	125.2	127.3	124.2	132.0	112.5	134.8	141.9		
112.9	114.5	115.6			134.2	128.4	127.9	132.7	120.7	137.3	115.6	127.8	117.5	116.4	
121.2	112.1	133.6	120.9	141.5	124.0	139.7	138.3	142.0	134.8	132.1	128.6	145.3	132.8	131.7	
115.9	113.0	112.6	119.8	117.7	125.7	131.1	131.7	120.0	133.0	117.5	122.6	136.4	128.4	124.1	
					127.9	125.3	127.8	116.2	131.7	129.9	118.1	127.4	133.6		
118.1	116.0	123.2	121.2	119.5	126.2	132.8	125.3	137.9	138.4	126.6	130.7	135.7	133.4	122.6	
					118.3	116.1	121.1	133.6	126.9	131.5	138.4	132.7	144.4	137.3	
118.1	115.6	119.7	121.8	123.4	131.7	130.8	141.9	134.1	132.6	130.8	128.2	137.0	135.4	130.6	Gen. Av.
116.2	106.8	112.3	108.7	107.9	164.0	155.4	154.1	144.9	137.5						
120.5	122.1	122.4	125.0	118.1	132.7	123.0	122.0	116.0	117.4	131.0	119.4	110.4	125.0		
					134.2	115.4	143.9	123.8	126.8	126.4	130.9	123.1	133.5	118.0	
106.0	116.4	127.9	126.0	112.8	129.0	119.5	129.6	131.4	128.5	119.6	122.6	123.7	125.6	112.6	
120.4	116.4	112.6	119.6	114.9	133.9	136.1	127.7	123.4	121.3	133.6	139.7	135.9	137.9	138.7	
124.0	109.0	117.7	122.6	107.5	142.6	132.9	121.7	132.0	115.5	127.6	121.2	121.2	123.9	129.0	
132.0	143.1	129.3	129.5	132.2	122.7	123.0	115.3	114.5	126.0	128.0	119.7	104.7	129.7	127.6	
119.8	118.9	120.3	121.9	115.5	137.0	129.3	130.6	126.6	124.7	127.7	125.6	119.8	129.3	125.2	Gen. Av.

Table XVIII. gives the daily work for C. The first five series represent the daily control series. The groups of ten which follow are the reactions with distraction present. Sound was the first distraction, then light, and finally touch distraction. The stimulus was sound throughout the series. Each set of figures in the series of five represent the average of 50 reactions; the figures in the series of ten represent the average of 100 reactions. The general average of each series is given. On account of the size of the tables the tables for the other subjects are omitted. However, it was from this and other similar tables that the data for Tables I.–XVII. and Figs. 3–8 were obtained. See especially Tables VII., VIII., and XXI. for C, and Fig. 5.

TABLE XIX

To Show the Effect of Distraction Within the Experiment — Subject 4

Gen. Av. of Simple Reaction-time					Gen. Av. of Dist. Series. Stimulus, Light; Distraction, Light, Sound, or Touch									
1	2	3	4	5	1	2	3	4	5	6	7	8	9	10
222.4	215.5	213.7	212.3	212.9	223.7	217.6	219.7	219.4	222.3	221.3	222.9	223.2	222.7	223.2
19.1	17.6	10.3	9.2	8.8	23.6	18.0	16.2	17.3	19.6	22.2	21.8	18.9	18.6	18.4
2.3	*2.1*	*1.5*	*1.5*	*1.4*	*2.3*	*1.8*	*1.6*	*1.7*	*1.9*	*2.2*	*2.1*	*2.1*	*2.0*	*2.0*
(51)	(51)	(40)	(27)	(26)	(68)	(68)	(68)	(68)	(67)	(63)	(63)	(62)	(62)	(60)
Daily Control Series					Stimulus, Light; Distraction, Light									
226.8	218.0	215.7	214.9	217.1	230.9	219.1	220.9	221.6	228.3	224.2	224.8	222.2	226.2	224.7
Daily Control Series					Stimulus, Light; Distraction, Sound									
209.6	205.1	215.8	219.1	213.4	212.2	215.4	221.6	213.4	221.2	214.4	215.9	212.9	216.8	219.0
Daily Control Series					Stimulus, Light; Distraction, Touch									
211.6	211.0	206.9	205.3	206.1	210.2	214.6	212.6	218.5	220.2	218.4	223.1	217.1	216.3	222.2
Gen. Av. of the Three Series					Gen. Av. of the Three Series									
216.0	211.4	212.8	213.1	212.2	217.8	216.4	218.4	217.8	223.2	219.0	221.2	217.4	219.7	221.9
7.2	4.4	3.9	5.2	4.1	8.8	1.8	2.8	2.9	3.4	3.5	3.6	3.2	4.2	2.0
3.4	*2.1*	*1.9*	*2.5*	*1.9*	*4.2*	*0.8*	*1.3*	*1.3*	*1.6*	*1.7*	*1.7*	*1.5*	*2.0*	*0.9*

TABLE XX

To Show the Effect of Distraction within the Experiment

Subject *B*

Gen. Av. of Simple Reaction-time					Gen. Av. of Dist. Series.			Stimulus, Light; Distraction, Light, Sound, or Touch						
1	2	3	4	5	1	2	3	4	5	6	7	8	9	10
206.4	198.7	204.7	204.4	196.8	212.0	205.8	206.6	209.7	207.5	212.5	210.3	211.2	215.0	211.7
8.1	8.1	11.0	10.5	6.6	12.7	10.6	8.8	12.6	11.7	12.1	11.6	9.9	11.3	12.1
1.4	*1.4*	*2.0*	*2.1*	*1.4*	*1.8*	*1.5*	*1.2*	*1.7*	*1.6*	*1.7*	*1.7*	*1.5*	*1.7*	*1.8*
(22)	(22)	(21)	(17)	(15)	(35)	(35)	(35)	(35)	(34)	(33)	(33)	(33)	(33)	(33)
Daily Control Series								Stimulus, Light; Distraction, Light						
203.3	193.5	198.6	197.3	193.8	208.3	206.3	207.8	209.6	210.1	212.8	210.8	212.1	214.4	212.8
Daily Control Series								Stimulus, Light; Distraction, Sound						
212.9	203.9	212.9	212.8	202.9	214.5	200.5	200.4	203.1	202.5	205.0	207.2	203.9	213.9	203.6
Daily Control Series								Stimulus, Light; Distraction, Touch						
206.8	210.6	212.4	209.1	193.7	218.4	208.8	210.1	216.5	206.3	220.1	212.2	215.7	217.5	216.8
Gen. Av. of the Three Series														
207.7	202.7	207.6	206.1	196.8	213.7	205.2	202.8	209.7	206.3	212.6	210.1	213.9	215.3	211.1
3.5	6.1	6.4	6.2	4.2	3.6	3.1	4.9	4.5	2.5	5.1	1.9	4.5	1.5	4.9
1.6	*2.9*	*3.1*	*2.9*	*2.0*	*1.7*	*1.4*	*2.3*	*2.1*	*1.2*	*2.4*	*0.9*	*2.1*	*0.7*	*2.4*

TABLE XXI

To Show the Effect of Distraction within the Experiment

Subject *C*

Gen. Av. of Simple Reaction-time					Gen. Av. of Dist. Series.			Stimulus, Sound; Distraction, Sound, Light or Touch						
1	2	3	4	5	1	2	3	4	5	6	7	8	9	10
123.0	121.8	124.4	123.8	122.8	149.4	140.9	138.3	149.0	145.9	141.5	142.2	144.0	147.0	145.6
10.0	10.8	7.5	5.1	8.6	23.1	16.7	15.4	19.5	16.6	13.2	16.4	17.5	15.8	16.6
1.4	*1.7*	*1.2*	*0.9*	*1.6*	*2.7*	*1.9*	*1.8*	*2.3*	*1.9*	*1.4*	*1.9*	*2.1*	*1.9*	*2.0*
(35)	(35)	(29)	(22)	(22)	(53)	(53)	(53)	(53)	(53)	(52)	(51)	(51)	(51)	(48)
Daily Control Series								Stimulus, Sound; Distraction, Sound						
126.5	124.5	127.7	124.1	125.5	155.3	145.3	141.5	157.4	158.5	146.3	147.0	142.8	148.6	151.4
Daily Control Series								Stimulus, Sound; Distraction, Light						
118.8	115.6	119.7	121.8	123.4	131.7	130.8	141.9	134.1	132.6	130.8	128.1	136.9	135.4	130.6
Daily Control Series								Stimulus, Sound; Distraction, Touch						
119.8	118.9	120.3	121.9	115.5	137.0	129.3	130.6	126.6	124.7	127.7	125.6	119.8	129.3	125.2
Gen. Av. of the Three Series														
121.1	119.4	122.4	122.9	120.5	141.3	135.1	138.0	139.4	138.6	134.9	133.6	133.2	137.8	139.1
3.0	3.1	3.4	1.1	4.3	9.3	6.8	2.7	8.7	12.6	7.6	9.0	9.2	7.3	6.9
1.5	*1.5*	*1.7*	*0.5*	*2.1*	*4.5*	*3.4*	*1.3*	*4.1*	*6.1*	*3.7*	*4.4*	*4.5*	*3.6*	*3.4*

TABLE XXII

To Show the Effect of Distraction within the Experiment

Subject *D*

Gen. Av. of Simple Reaction-time.					Gen. Av. of Dist. Series. Stimulus, Sound; Distraction, Sound									
1	2	3	4	5	1	2	3	4	5	6	7	8	9	10
131.6	125.9	124.6	124.8	125.3	153.5	145.9	149.0	151.2	146.5	144.5	142.6	138.9	137.2	143.2
8.1	8.4	7.2	4.5	7.1	7.1	11.6	11.9	10.3	7.1	10.4	13.1	13.6	8.5	8.8
1.8	*2.0*	*1.8*	*1.4*	*2.6*	*1.4*	*2.3*	*2.3*	*2.0*	*1.4*	*2.1*	*2.7*	*2.8*	*1.7*	*1.9*
(13)	(12)	(10)	(7)	(5)	(17)	(17)	(17)	(17)	(17)	(16)	(16)	(16)	(16)	(15)

TABLE XXIII

To Show the Effect of Distraction within the Experiment

Subject *E*

Gen. Av. of Simple Reaction-time					Gen. Av. of Dist. Series.			Stimulus, Sound; Distraction, Sound, Light, or Touch						
1	2	3	4	5	1	2	3	4	5	6	7	8	9	10
124.1	128.3	118.4	117.8	115.2	123.1	122.7	125.1	122.6	125.4	125.1	124.5	122.0	123.9	125.1
10.0	9.5	7.7	7.9	7.2	15.4	16.4	15.2	15.9	14.7	15.1	13.3	12.0	13.8	15.8
2.1	*2.0*	*1.6*	*1.6*	*1.4*	*2.1*	*2.3*	*2.1*	*2.2*	*2.0*	*2.1*	*1.8*	*1.7*	*1.9*	*2.3*
(16)	(16)	(16)	(16)	(16)	(35)	(35)	(35)	(35)	(34)	(34)	(34)	(34)	(34)	(33)
Daily Control Series								Stimulus, Sound; Distraction, Sound						
130.6	127.7	122.8	124.5	118.6	141.4	142.9	141.9	144.6	141.9	140.7	140.3	135.5	140.5	142.6
Daily Control Series								Stimulus, Sound; Distraction, Light						
116.6	119.1	113.2	109.7	110.7	110.8	110.3	114.9	115.3	115.2	116.6	114.1	115.1	113.8	115.3
Daily Control Series								Stimulus, Sound; Distraction, Touch						
113.5	103.9	111.4	107.4	109.1	110.8	107.4	112.2	108.9	113.3	112.2	115.5	111.3	112.3	112.2
Gen. Av. of the Three Series														
120.2	116.9	118.8	112.9	112.8	121.0	120.2	123.0	122.9	123.4	123.1	123.3	120.6	122.2	123.3
6.9	8.7	5.7	6.8	3.9	12.9	15.1	12.6	14.4	15.6	11.7	11.3	9.5	15.5	12.4
3.7	*4.2*	*2.8*	*3.1*	*1.9*	*6.3*	*7.4*	*6.1*	*7.0*	*7.6*	*5.7*	*5.5*	*4.6*	*7.6*	*6.1*

TABLE XXIV

To Show the Effect of Distraction within the Experiment — Subject *F*

Gen. Av. of Simple Reaction-time					Gen. Av. of Dist. Series.	Stimulus, Sound; Distraction, Sound, Light, or Touch								
1	2	3	4	5	1	2	3	4	5	6	7	8	9	10
121.0	113.8	117.8	113.3	112.8	122.6	120.7	119.4	120.2	121.5	119.6	117.1	117.6	117.5	117.3
6.9	6.6	6.2	5.3	6.9	10.0	11.3	10.6	11.7	10.6	9.9	7.8	9.5	6.4	7.0
1.4	*1.4*	*1.3*	*1.1*	*1.4*	*1.7*	*1.9*	*1.8*	*1.9*	*1.8*	*1.8*	*1.4*	*1.7*	*1.1*	*1.2*
(16)	(16)	(16)	(16)	(16)	(24)	(24)	(24)	(24)	(24)	(23)	(23)	(23)	(23)	(23)
Daily Control Series					Stimulus, Sound; Distraction, Sound									
121.4	112.3	116.7	113.1	114.1	129.2	126.6	125.1	126.8	127.8	123.5	119.0	121.5	117.4	119.6
Daily Control Series					Stimulus, Sound; Distraction, Light									
115.8	111.4	117.3	110.7	105.2	113.2	108.7	108.9	109.4	111.7	113.5	110.7	108.6	116.7	112.2
Daily Control Series					Stimulus, Sound; Distraction, Touch									
124.7	117.8	119.9	115.8	117.0	121.4	123.7	121.5	120.8	121.1	120.3	121.6	121.8	118.5	118.5
Gen. Av. of the Three Series					Gen. Av. of the Three Series									
120.6	113.8	117.9	113.2	112.1	121.6	119.6	118.5	119.0	120.2	119.1	117.1	117.3	117.5	116.7
3.2	2.6	1.1	1.7	4.6	5.4	7.3	6.4	6.4	5.6	3.7	4.2	5.8	0.6	3.0
1.5	*1.2*	*0.5*	*0.8*	*2.2*	*2.6*	*3.5*	*3.1*	*3.1*	*2.7*	*1.8*	*2.0*	*2.8*	*0.03*	*1.4*

Table XXVI. below is a summary of Tables XIX. to XXIV. The averages are arranged here for purposes of comparison. The distraction was sound, light, or touch as previously indicated in Tables XIX to XXV.

TABLE XXVI

Gen. Av. of Simple Reaction-time					Gen. Av. of Reaction-time with Distraction Present										Subject
1	2	3	4	5	1	2	3	4	5	6	7	8	9	10	
222.4	215.5	213.7	212.3	212.9	223.7	217.6	219.7	219.4	222.3	221.3	222.9	223.2	222.7	223.2	*A*
206.4	198.7	204.7	204.4	196.8	212.0	205.8	206.6	209.7	207.5	212.5	210.3	211.2	215.0	211.7	*B*
123.0	121.8	124.4	123.8	122.8	149.4	140.9	138.3	149.0	145.9	141.5	142.2	144.0	147.0	145.6	*C*
131.6	125.9	124.6	124.8	125.3	153.5	145.9	149.0	151.2	146.5	144.5	142.6	138.9	137.2	143.2	*D*
124.1	128.3	118.4	117.8	115.2	123.1	122.7	125.1	122.6	125.4	125.1	124.5	122.0	123.9	125.1	*E*
121.0	113.8	117.8	113.3	112.8	112.6	120.7	119.4	120.2	121.5	119.6	117.1	117.6	117.5	117.3	*F*

TABLE XXXII

Subject *A*

	Preliminary Test (Nov. 17)					*Final Test (Mar. 25)*				*Gain or Loss*	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*
Light	None	* 261.4	20.5	5.1	.078	213.3	5.7	1.9	.026	48.1	14.8
"	Light	343.1	13.2	3.4	.073	207.7	5.7	2.1	.027	135.6	7.4
"	None	224.0	9.0	3.3	.040						
"	Sound	241.9	16.5	6.1	.068	212.9	9.7	3.6	.045	29.0	6.8
"	None	213.1	16.1	9.5	.075						
"	Touch	238.0	27.3	10.1	.114	221.8	8.9	3.3	.040	16.2	18.4
Sound	None	164.4	19.8	5.0	.120	149.7	6.0	2.2	.040	14.7	13.8
"	None	177.1	18.4	10.8	.103						
"	Sound	225.8	38.8	10.1	.171	150.7	9.4	3.5	.062	75.1	29.4
"	None	134.1	11.5	6.8	.085						
"	Light	159.0	6.5	2.4	.040	147.3	5.0	1.8	.033	11.7	1.5
"	None	134.1	11.5	6.8	.085						
"	Touch	162.8	6.4	2.3	.039	158.7	3.8	1.4	.024	4.1	2.6
Touch	None	124.5	7.6	2.8	.061	132.8	11.5	4.2	.086	– 8.3	– 3.9
"	Touch	201.7	1.4	0.5	.006	168.1	8.5	3.1	.018	33.6	– 7.1

* The reaction time with no distraction is the control test for the reaction following in the line below and included within the bracket. This was necessary when more than one period was used.

TABLE XXXIII

Subject *B*

		Preliminary Test (Dec. 10)				*Final Test (Mar. 1)*				*Gain or Loss*	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*
Light	None	212.8	3.9	1.9	.018	207.3	15.3	5.6	.070	5.5	−11.4
"	Light	* 260.3	13.9	3.5	.053	217.4	8.2	3.0	.037	42.9	5.7
"	None	206.4	8.8	3.7	.042						
"	Sound	208.9	3.6	1.3	.016	211.5	5.6	2.5	.026	− 2.6	− 2.0
"	None	206.4	8.8	3.7	.042						
"	Touch	225.9	8.9	3.0	.035	219.9	14.7	5.4	.066	6.0	− 5.8
Sound	None	127.4	8.2	4.8	.064	137.1	6.0	2.0	.043	− 9.7	2.2
"	Sound	152.0	11.8	3.0	.077	151.3	10.9	3.7	.072	− 0.7	0.9
"	None	129.8	9.0	3.3	.069						
"	Light	132.4	6.5	2.4	.049	170.4	15.2	6.4	.089	−38.0	− 8.7
"	None	123.7	5.5	1.9	.044						
"	Touch	157.9	16.1	5.5	.101	149.6	6.4	2.3	.042	8.3	9.7
Touch	None	116.7	5.4	2.0	.046	111.5	0.0	2.0	.049	0.2	− 0.1
"	Touch	150.9	7.2	2.6	.047	125.2	15.7	6.6	.120	20.7	8.0

* The reaction time with no distraction is the control test for the reaction following in the line below and included within the bracket. This was necessary when more than one period was used.

TABLE XXXIV

Subject *C*

		Preliminary Test (Nov. 14–17)				*Final Test (Mar. 30)*				*Gain or Loss*	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*
Light	None	255.9	23.9	6.2	.093	188.0	8.2	3.0	.043	67.9	15.7
"	Light	247.3	29.3	7.6	.118	199.2	4.3	1.6	.021	48.1	25.0
"	None	243.5	1.4	0.8	.005						
"	Sound	248.6	19.6	5.0	.078	192.8	4.3	1.6	.022	55.8	15.3
"	None	192.1	2.1	1.0	.010						
"	Touch	201.9	23.2	8.6	.114	202.7	6.4	2.3	.031	– 0.8	16.8
Sound	None	139.0	7.6	1.9	.054	115.2	3.9	1.4	.033	23.8	3.7
"	Sound	206.0	19.7	4.7	.095	118.8	5.8	2.1	.048	87.2	13.9
"	None	128.8	15.9	9.4	.123						
"	Light	186.6	11.7	4.3	.062	124.7	5.9	2.2	.047	61.9	5.8
"	None	133.8	4.4	2.6	.032						
"	Touch	149.4	17.4	10.2	.116	125.0	5.7	2.1	.045	24.4	11.7
Touch	None	180.9	33.1	8.6	.182	110.1	5.9	2.5	.053	70.8	27.2
"	Touch	190.0	31.8	8.2	.167	108.6	5.1	1.7	.046	81.4	26.7

TABLE XXXV

Subject *D*

		Preliminary Test (Nov. 21–25)				*Final Test (Feb. 12)*				*Gain or Loss*	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*
Light	None	275.1	18.4	4.8	.066	192.4	12.2	4.1	.063	82.7	6.2
"	None	265.6	34.7	20.5	.130						
"	Light	295.4	42.0	10.9	.010	212.8	19.9	6.7	.093	82.6	22.1
"	None	186.4	12.9	6.2	.069						
"	Sound	191.3	16.5	6.1	.086	205.8	9.6	3.5	.046	−14.5	6.9
"	None	186.4	16.3	7.8	.087						
"	Touch	218.3	8.5	3.1	.038	198.8	6.3	1.7	.031	19.5	2.2
Sound	None	179.6	16.0	4.1	.089	117.3	2.8	1.0	.023	62.3	13.2
"	None	134.4	8.1	4.8	.060						
"	Sound	166.7	17.3	4.5	.103	149.8	11.0	4.1	.073	16.9	6.3
"	None	124.4	4.6	2.2	.036						
"	Light	131.8	11.4	4.2	.086	162.5	6.9	2.3	.042	−30.7	4.5
"	None	136.9	2.2	1.3	.016						
"	Touch	143.4	12.8	3.6	.089	157.2	20.4	6.5	.129	−13.8	− 7.6
Touch	None	162.7	23.0	5.7	.141	103.1	6.8	2.2	.065	69.6	16.2
"	None	149.7	0.7	0.4	.004						
"	Touch	165.5	8.1	2.1	.048	147.6	14.8	5.5	.100	17.6	− 6.7

TABLE XXXVI

		Preliminary Test (Dec. 12)				*Final Test (Mar. 23)*				Subject *E* *Gain or Loss.*	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*MV.*
Light	None	196.4	3.3	1.2	.016	174.5	5.6	1.8	.032	21.9	— 2.3
"	Light	206.9	4.4	1.6	.021	195.9	8.6	2.9	.043	11.0	— 4.2
"	Sound	204.8	10.9	3.5	.053	197.8	7.8	2.6	.039	7.0	3.1
"	Touch	211.4	3.6	2.6	.017	193.4	2.8	0.9	.014	18.0	0.8
Sound	None	141.5	7.4	2.5	.053	111.4	3.3	1.1	.029	30.1	4.1
"	Sound	153.2	6.6	2.4	.043	124.2	8.4	2.8	.067	29.0	— 1.8
"	None	123.6	14.6	5.4	.118						
"	Light	143.1	12.5	1.3	.087	105.7	8.5	6.3	.080	37.4	4.0
"	Touch	149.6	10.4	3.8	.069	111.3	5.5	1.3	.049	38.3	4.9
Touch	None	153.7	11.5	4.2	.074	116.6	8.9	3.3	.076	37.1	2.6
"	Touch	164.2	1.2	0.4	.007	133.5	6.4	2.2	.047	30.7	— 5.2

TABLE XXXVII

Subject *F*

		Preliminary Test (Jan. 5–8)				*Final Test (Mar. 1)*				*Gain or Loss*	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*
Light	None	218.1	10.7	4.0	.049	213.3	6.8	2.5	.032	4.8	3.9
"	Light	260.9	21.3	7.2	.081	244.1	14.2	5.2	.058	16.8	7.1
"	None	204.7	10.7	3.6	.052						
"	Sound	269.6	18.8	5.6	.069	224.7	5.2	1.3	.023	44.9	13.6
"	Touch	260.5	12.8	4.3	.049	239.8	15.5	5.3	.064	20.7	– 2.7
Sound	None	140.0	3.1	1.1	.022	123.9	8.3	3.1	.066	16.1	– 5.2
"	Sound	156.6	10.9	4.0	.069	133.9	4.9	1.5	.036	22.7	6.0
"	Light	167.1	5.2	1.9	.031	121.1	5.5	2.0	.045	46.0	– 0.3
"	Touch	166.4	28.3	11.8	.170	135.0	5.7	1.5	.042	31.4	22.6
Touch	None	125.9	9.8	3.6	.077	114.7	5.2	1.9	.045	11.2	4.6
"	Touch	163.9	6.7	2.5	.047	131.1	17.3	5.5	.131	32.8	–10.6

TABLE XXXVIII

		Preliminary Test (Dec. 26)				*Final Test (March 10)*				Subject *V* *Gain or Loss*	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*
Light	None	219.6	14.3	5.3	.065	201.8	3.6	1.3	.017	17.8	10.7
"	Light	275.4	11.2	4.1	.040	249.5	9.1	3.3	.036	25.9	2.1
"	Sound	254.2	18.6	6.9	.073	236.2	13.9	5.1	.058	18.0	4.7
"	Touch	239.9	18.2	6.7	.076	228.8	6.5	2.2	.028	10.8	11.7
Sound	None	150.0	9.9	3.6	.066	139.6	4.5	1.6	.032	10.2	5.4
"	Sound	213.2	14.7	5.4	.068	193.9	12.9	4.4	.066	19.3	1.8
"	Light	157.7	7.8	2.9	.049	148.7	4.5	1.6	.030	9.0	3.3
"	Touch	160.2	13.0	4.4	.081	152.2	9.9	3.6	.065	8.0	3.1
Touch	None	158.9	14.9	5.5	.093	139.7	2.2	0.8	.015	19.2	12.7
"	Touch	174.3	9.1	3.3	.052	182.2	8.8	3.0	.048	7.9	0.3

TABLE XXXIX

		Preliminary Test (Dec. 15–19)				*Final Test (April 2–3)*				Subject *W* *Gain or Loss*	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*
Light	None	251.3	22.7	8.4	.090	237.2	3.5	1.3	.014	14.1	19.2
"	Light	255.9	18.1	6.1	.070	285.5	26.2	9.7	.088	−39.6	− 8.1
"	None	219.1	14.3	5.3	.065						
"	Sound	239.2	9.6	3.5	.040	258.8	12.4	4.6	.047	−19.6	− 2.8
"	None	219.1	14.3	5.3	.065						
"	Touch	238.1	22.7	7.7	.095	268.8	9.4	3.5	.034	−30.7	13.3
Sound	None	129.2	6.1	2.2	.047	135.4	16.9	6.2	.124	− 6.2	−10.8
"	Sound	159.7	16.5	5.6	.103	192.8	23.2	8.6*	.120	−33.1	− 6.7
"	None	133.9	5.0	1.7	.037						
"	Light	152.0	12.9	4.8	.084	139.2	3.4	1.2	.030	12.8	9.5
"	Touch	147.8	9.8	3.3	.066	143.9	4.4	1.6	.030	3.9	5.4
Touch	None	147.9	4.5	1.6	.030	154.2	8.4	3.1	.054	− 6.3	− 3.9
"	Touch	186.1	10.9	4.0	.053	176.3	4.7	1.7	.026	9.8	6.2

* Due to two long sets, 226.4 and 213.3.

TABLE XL

Subject *X*

		Preliminary Test (Jan. 2)				*Final Test (Mar. 14)*				*Gain or Loss*	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*
Light	None	219.5	16.0	5.5	.072	237.6	6.8	2.5	.028	−18.1	9.2
"	Light	283.9	21.7	8.0	.076	273.4	14.3	5.3	.052	10.5	7.4
"	Sound	263.2	5.9	2.2	.022	267.7	4.3	1.4	.016	− 4.5	1.6
"	Touch	263.3	15.2	5.6	.057	250.5	5.2	1.9	.020	12.8	10.0
Sound	None	175.7	23.7	8.0	.134	172.7	17.5	4.9	.101	3.0	6.2
"	Sound	236.7	9.5	3.5	.040	220.2	8.7	2.9	.039	16.4	0.8
"	Light	199.3	6.3	2.1	.031	181.2	6.1	2.2	.033	18.1	0.2
"	Touch	194.2	21.4	6.8	.110	168.8	14.0	4.7	.082	25.4	7.4
Touch	None	180.7	13.1	4.8	.072	139.5	7.9	2.9	.056	41.2	5.2
"	Touch	191.4	13.2	4.9	.068	169.2	4.9	1.8	.028	22.2	8.3

TABLE XLI

		Preliminary Test (Jan. 10)				Final Test (Mar. 31)				Subject Y	
										Gain or Loss	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*
Light	None	188.2	11.0	3.5	.058	215.9	13.9	4.7	.064	−27.7	− 2.9
"	Light	296.7	26.8	7.0	.090	236.2	11.2	4.1	.047	60.5	15.6
"	Sound	213.9	12.7	4.3	.059	227.8	9.3	3.4	.040	−13.9	3.6
"	Touch	207.2	7.9	2.7	.038	217.0	11.5	4.2	.052	− 9.8	− 3.6
Sound	None	136.5	11.9	4.3	.087	134.5	7.7	2.4	.057	2.0	4.2
"	Sound	169.7	20.8	7.1	.122	194.9	15.5	6.5	.079	−25.2	5.3
"	Light	154.8	9.7	3.3	.062	151.3	3.6	1.3	.023	3.5	6.1
"	Touch	148.7	16.9	5.4	.113	159.2	28.3	8.5	.177	−10.5	−11.4
Touch	None	133.2	11.3	3.8	.084	124.6	8.0	2.9	.064	8.6	3.3
"	Touch	17.31	27.6	9.4	.159	143.4	5.6	2.1	.039	29.7	22.0

TABLE XLII

Subject *Z*

		Preliminary Test (Feb. 10)				*Final Test (Feb. 1)*				*Gain or Loss*	
Stim.	*Dist.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*	*P.E.*	*P.C.*	*Time*	*M.V.*
Light	None	250.8	9.2	3.4	.036	255.9	3.5	1.3	.013	– 5.1	5.7
"	Light	262.4	23.5	8.7	.089	297.5	13.8	4.7	.046	–35.1	9.7
"	Sound	233.2	11.4	4.2	.048	255.6	9.6	3.2	.037	–22.4	1.8
"	Touch	232.5	11.8	4.9	.050	261.8	18.5	6.3	.070	–29.3	– 6.7
Sound	None	159.6	9.9	3.3	.062	148.9	6.7	2.5	.044	10.7	3.2
"	Sound	160.7	13.6	4.6	.084	181.3	10.9	3.7	.060	–20.6	2.7
"	Light	171.4	15.2	5.6	.088	167.7	7.4	2.5	.044	3.7	7.8
"	Touch	188.3	6.9	2.6	.036	152.2	5.2	1.1	.034	36.1	1.7
Touch	None	167.1	19.4	7.2	.116	136.7	6.4	2.3	.046	30.4	13.0
"	Touch	182.3	17.3	6.4	.094	164.6	19.8	6.7	.120	17.7	– 2.5

Z thought touch distraction was an aid more than a distraction as it seemed to tell about when the stimulus would occur.

TABLE XLIII

		Subjects													
		A		*B*		*C*		*D*		*E*		*F*		*Gain or Loss*	
Stimulus	*Distraction*	*Time*	*M.V.*	*Time*	*M.V.*	*Time*	*M.V.*	*Time*	*M.V.*	*Time*	*M.V.*	*Time*	*M.V.*	*Time*	*M.V.*
Light	None	48.1	14.8	5.5	−11.4	67.9	15.7	82.7	6.2	21.9	2.3	4.8	3.9	38.5	29.1
"	Light	145.6	19.4	42.6	5.7	48.1	25.0	82.6	−15.7	11.0	− 4.2	16.8	4.5	57.8	37.5
"	Sound	29.0	6.8	− 2.6	− 2.0	45.8	5.3	−14.5	6.9	7.0	3.1	24.9	6.1	14.9	18.3
				2.9	− 4.2										
"	Touch	16.2	18.4	6.0	− 6.6	− 0.8	16.8	19.5	2.2	18.0	0.8	20.7	7.9	13.3	6.9
Sound	None	14.7	13.8	− 9.7	2.2	23.8	4.5	62.3	13.2	12.2	11.3	16.1	− 5.2	18.2	14.7
"	Sound	75.1	28.4	0.7	0.9	87.2	13.9	16.9	16.3	29.0	6.0	22.7	6.9	38.6	28.4
"	Light	11.7	1.5	−38.0	− 8.7	61.9	5.8	− 8.3	0.3	37.4	5.0	46.0	− 0.3	18.4	30.0
"	Touch	4.1	− 0.6	8.3	9.7	24.4	11.7	−15.4	−16.0	38.3	4.9	47.1	35.8	16.1	17.8
Touch	None	− 8.3	− 3.9	5.2	− 0.1	70.8	27.2	69.6	16.2	37.1	2.5	11.2	4.6	30.9	28.2
"	Touch	33.6	− 7.1	25.7	− 8.5	81.4	26.7	17.9	− 6.7	30.7	− 5.2	32.8	−10.6	37.0	13.1

TABLE XLIV

		Subjects									
		W		*Z*				*V*		*X*	

		W		*Z*				*V*		*X*		*Gain or Loss*	
Stimulus	*Distraction*	*Time*	*M.V.*	*Time*	*M.V.*	*Time*	*M.V.*	*Time*	*M.V.*	*Time*	*M.V.*	*Time*	*M.V.*
Light	None	14.1	19.2	– 5.1	5.7	–27.7	– 2.9	17.8	10.7	–18.1	9.2	– 3.8	15,8
"	Light	–39.6	– 8.1	–35.1	9.7	60.5	15.6	25.9	2.1	10 5	7.4	4.4	33.4
"	Sound	–19.6	– 2.8	–22.3	1.8	–13.9	3.4	18.0	4.7	– 4.5	1.6	– 8.5	12.4
"	Touch	–30.7	13.3	–29.3	– 6.7	– 9.8	– 3.6	10.5	11.7	12.8	10.0	– 9.1	16.8
Sound	None	– 6.2	–10.8	10.7	3.2	2.0	4.2	10.3	5.4	3.0	6.2	3.9	5.2
"	Sound	–33.1	– 6.7	–20.6	2.7	–24.8	5.3	19.3	1.8	16.4	0.8	–10.6	20.7
"	Light	12.8	9.5	3.7	7.8	– 2.5	6.1	9.0	3.3	18.1	0.2	8.2	6.1
"	Touch	3.9	5.4	36.1	1.7	–10.5	–11.4	8.0	3.1	25.4	7.4	12.6	16.5
Touch	None	– 6.3	– 3.9	30.4	13.0	8.6	3.3	19.2	12.7	41.2	5.2	18.6	14.0
"	Touch	9.8	6.2	17.5	– 2.5	29.7	22.0	– 7.9	– 0.3	22.2	8.3	14.3	10.7

TABLE XLVIII

		C		*D*		*E*		*F*			
Stim.	*Dist.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Av. Diff. in Time*	*Av. Diff. in Var.*
Sound	None	23.8	3.7	62.3	13.2	30.1	4.1	16.1	– 5.2	33.1	4.0
"	Sound	87.2	13.9	16.9	6.3	29.0	–1.8	22.7	6.0	38.9	6.1
"	Light	61.9	5.8	– 8.3	0.3	57.4	4.0	46.0	– 0.3	34.2	2.5
"	Touch	24.4	11.7	–15.4	–16.0	38.3	4.9	31.4	22.6	19.7	9.8

TABLE XLIX

		A		B			
Stim.	*Dist.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Av. Diff. in Time*	*Av. Diff. in Time*
Light	None	48.1	14.8	5.5	−11.4	26.8	1.7
"	Light	145.6	19.4	42.9	5.7	84.3	12.6
"	Sound	29.0	6.2	− 2.6	− 2.0	13.2	2.1
"	Touch	16.2	18.4	6.0	− 6.6	11.1	5.9

TABLE L

		A		B			
Sound	None	27.4	12.4	− 9.7	2.2	8.9	7.3
"	Sound	75.1	29.4	− 1.1	−0.9	37.0	14.3
"	Light	11.7	1.5	−38.0	−8.7	−13.2	3.6
"	Touch	4.1	2.6	8.3	9.7	6.4	6.2

TABLE LI

		W		Z		Y		V		X			
Stim.	*Dist.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Av. Diff. in Time*	*Av. Diff. in Var.*
Light	None	14.1	19.2	− 5.1	5.7	−27.7	2.9	17.8	10.7	−18.1	9.2	−4.0	9.5
"	Light	−39.6	− 8.1	−35.1	9.7	60.5	15.6	25.3	2.1	10.5	7.4	4.4	5.4
"	Sound	−19.6	− 2.8	−22.4	1.6	−13.9	3.4	18.0	4.7	− 4.5	1.6	−8.5	1.7
"	Touch	−30.7	13.3	−29.3	− 6.7	− 9.8	− 3.6	10.5	11.7	12.8	10.0	−9.3	4.9

TABLE LII

		W		*Z*		*Y*		*V*		*X*			
Sound	None	– 6.2	–10.8	10.7	3.2	2.0	4.2	10.2	5.4	3.0	6.2	3.9	1.6
"	Sound	–33.1	– 6.7	–20.6	2.7	–25.2	5.3	19.3	1.9	16.4	0.8	–8.6	0.6
"	Light	12.8	9.5	3.7	7.8	3.5	6.1	9.0	3.3	18.1	0.2	9.4	5.4
"	Touch	3.9	5.4	36.1	1.7	–10.5	–11.4	8.0	3.1	25.4	7.4	12.6	1.2

TABLE LIII

		C		*D*		*E*		*F*			
Stim.	*Dist.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Diff. in Time*	*Diff. in Var.*	*Av. Diff. in Time*	*Av. Diff. in Var.*
Light	None	67.9	15.7	82.7	6.2	21.9	–2.3	4.8	3.9	44.3	5.9
"	Light	–48.1	25.0	82.6	–15.7	11.0	–4.2	16.8	7.1	39.6	3.0
"	Sound	55.7	15.3	–14.5	6.9	7.0	3.1	44.9	13.6	23.2	9.7
"	Touch	– 0.8	16.8	19.5	2.2	18.0	0.8	20.7	– 2.7	14.3	4.5

TABLE LVII

Subj.	*Stimulus Light*	*Stim. Light, Dist. Light*	*Stim. Light, Dist. Sound*	*Stim. Light, Dist. Touch*
PRELIMINARY TEST				
A	261.4σ	343.3σ	241.9σ	238.0σ
	5.1	*3.4*	*6.1*	*10.1*
B	212.8	260.3	208.9	225.9
	1.9	*3.5*	*1.3*	*3.0*
AFTER TRAINING IN REACTING TO LIGHT WITH LIGHT DISTRACTION				
A	209.8	195.0	218.0	
	1.5	*2.3*	*1.7*	
B	195.0	199.4	196.5	
	1.7	*1.5*	*2.6*	
AFTER TRAINING IN REACTING TO LIGHT WITH SOUND DISTRACTION				
A	217.2		218.8	224.7
	3.2		*1.9*	*1.6*
B	200.9		201.6	222.6
	1.9		*1.7*	*1.6*
AFTER TRAINING IN REACTING TO LIGHT WITH TOUCH DISTRACTION				
A	213.3	207.7	212.9	221.8
	1.9	*2.1*	*3.6*	*3.3*
B	207.3	217.4	211.5	219.9
	5.6	*3.0*	*2.5*	*5.4*

TABLE LVIII

PRELIMINARY TEST.

Subj.	*Stimulus Light*	*Stim. Light Dist. Light*	*Stim. Light, Dist. Sound*	*Stim. Light, Dist. Touch*
C	139.0σ	206.0σ	186.6σ	149.4σ
	1.9	*4.7*	*4.3*	*10.2*
D	179.6	166.7	154.2	141.8
	4.1	*4.5*	*2.4*	*2.1*
AFTER TRAINING IN REACTING TO SOUND WITH SOUND AS A DIST.				
C	130.9	131.8	148.2	151.2
	1.7	*2.2*	*2.5*	*2.2*
D	117.3	149.3	162.5	157.2
	1.0	*4.1*	*2.3*	*6.5*
AFTER TRAINING IN REACTING TO SOUND WITH LIGHT AS A DIST.				
C	119.6		130.9	121.8
	0.8		*1.2*	*1.5*
AFTER TRAINING IN REACTING TO SOUND WITH TOUCH AS A DIST.				
C	115.2	118.8	124.7	125.0
	1.4	*2.1*	*2.2*	*2.1*

TABLE LIX

Subj.	*Stimulus Sound*	*Stim. Sound, Dist. Sound*	*Stim. Sound, Dist. Light*	*Stim. Sound, Dist. Touch*
Preliminary Test				
E	141.5σ	153.2σ	143.1σ	149.6σ
	2.5	*2.4*	*1.3*	*3.8*
F	140.0	156.6	167.1	166.4
	1.1	*4.0*	*1.9*	*11.8*
After Training in Reacting in Sound				
E	139.0	153.7	150.1	145.2
	3.3	*2.6*	*1.9*	*2.8*
F	121.2	147.4		
	0.6	*3.6*		
After Training in Rracting to Sound with Sound as a Dist.				
E	118.6	126.3	119.5	126.3
	1.3	*2.5*	*1.9*	*1.6*
F	117.5	120.4	122.5	120.5
	2.4	*0.8*	*2.1*	*1.2*
After Training in Reacting to Sound with Light as a Dist.				
E	111.1		113.9	111.0
	1.5		*0.8*	*1.3*
F	104.3		101.6	108.1
	2.2		*0.9*	*0.8*
After Training in Reacting to Sound with Touch as a Dist.				
E	111.4	124.2	105.7	111.3
	1.1	*2.8*	*6.3*	*1.3*
F	123.9	133.9	121.1	135.0
	3.1	*1.5*	*2.0*	*1.5*

THE EFFECT OF HUMIDITY

ON NERVOUSNESS AND ON GENERAL EFFICIENCY

I

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PREFACE

The following study is part of an extensive investigation of the subject of ventilation in its various biological and mechanical aspects, carried on during the years 1913–1916 by the New York State Commission on Ventilation.[1] This Commission, appointed by the Governor of the State of New York at the request of the New York Association for Improving the Condition of the Poor, was enabled to carry on its work by the aid of the Elizabeth Milbank Anderson Fund. The other psychological experiments of the Commission, which were, like this one, planned by Professor Edward L. Thorndike and carried out under his direction, are described in full in a recent number of the Teachers College Contributions to Education, and briefly reviewed in the historical section of this monograph.

From the foregoing statement of the place of this study in the series of psychological investigations already made by the Commission, it will be evident how deeply the writer is indebted to Professor Thorndike for guidance and advice. She has great pleasure, moreover, in acknowledging her obligation to Professors J. McKeen Cattell, Robert S. Woodworth and Harry L. Hollingworth. Her thanks are also due Mr. George T. Palmer, Chief of the Investigating Staff, and Mr. Joseph Herzstein, Secretary of the Commission.

---

[1] Members of the Commission: Professor Charles-E. A. Winslow, Professor Frederick S. Lee, Professor Edward L. Thorndike, Mr. D. D. Kimball, Dr. James Alexander Miller, Professor Earle B. Phelps.

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THE EFFECT OF HUMIDITY ON NERVOUSNESS AND ON GENERAL EFFICIENCY

CHAPTER I

History of Investigations of the Effect of Indoor and Outdoor Atmospheric Conditions

The question of how man is affected by climate and by the weather has been a fruitful subject of discussion alike for philosophers and village wiseacres in all ages. In modern times we have found a new topic for general conversation in the subject of the effects of the indoor weather for which our heating and ventilating systems are responsible. Fortunately we are beginning to substitute a scientific treatment of the matter for the old speculative method.

It is evident that the problems connected with ventilation have been seriously considered only in modern times. The first aim of civilized man has always been to get warm air, rather than "good" air. Even the highly cultivated Greeks and Romans, whose extravagance and splendor were pointed out to us in our early classical education, never got beyond the problem of heating, and solved that rather badly.[1] In general, their heating arrangements were no different in principle from those of the Iroquois Indians or the Laplanders, who light a fire in the center of the apartment and let the smoke find its way out by a hole in the roof. Since the ancients commonly set braziers of burning charcoal about the room, the indoor smoke nuisance was never done away with, as is shown by the fact that Marcus Vitruvius Pollio in his De Architectura about 13–16 B.C. recommended dark mural decorations that would not be stained by smoke. The walls and floors of Roman palaces and baths were later heated by means of a network of flues leading from a central fire. Even with this hypocaust[2] system, ventilation was provided only by vent holes in the roof. The use of the chimney even in Italy does not seem to have been common before the twelfth century, and a deliberate attempt to ventilate a house is not recorded until 1660, when Sir Christopher Wren devised a very inferior plan for the House of Parliament.

---

[1] Cf. Bernan, Walter, "History of the Art of Heating and Ventilating," London, 1845. Cf. Joly, "Traité du Chauffage, de la Ventilation," Paris, 1873. Cf. Billings, "Ventilation and Heating," New York, 1893.

[2] Article Hypocausis in Dictionnaire des Antiquités (Daremberg et Saglio) Paris, 1899, 3^1.

Of course the phenomena accompanying the crowding of many living beings in a confined space had long been observed, but an explanation of the matter was not soon found. The ancients, according to Weisman,[3] generally attributed the death of animals confined in a closed space to the warming of the air. In 1674 Mayow taught that there was a "principle" in air, capable of supporting life and combustion. Lee[4] quoted him as ascribing the death of animals confined within closed spaces to their consumption of the "nitro-aerial spirit" of the air. "Boyle in 1680 showed that air must be constantly renewed to maintain life. Veratti in 1750 raised the question as to whether death in a confined space was caused by the diminution of the elasticity of the air or by a poisonous exhalation, which, leaving the body of the animal through respiration, carried with it a noxious principle, or by the destruction of the vital principle of the air. With reference to exhalations from the body, Bergman . . . writing in 1791 states: 'The lungs moreover add by their constant motion, various subtle particles by means of the absorbing vessels, and again by the exhaling vessels, carry off others.' . . . Writing of the effects of vitiation of air upon animals, Lavoisier states: 'If one encloses animals in a given quantity of air, they perish in it when they have absorbed or converted into carbon dioxide the greater part of the respirable portions of the air. To make respirable the vitiated air two things must be done: First, to remove from this air by the lime or caustic alkali, the portion of carbon dioxide that it encloses; second, to return to it a quantity of air that is eminently respirable equal to that which it has lost.' "[5]

The Oxygen and the Carbon Dioxide Theories

This statement of Lavoisier's formulates two of the earliest scientific theories of the harmful factors in bad ventilation, *i. e.*, the deficiency-of-oxygen theory and the superabundance-of-carbon-dioxide theory. Many experimenters from the time of Leblanc (1842) on, have found that the diminution of oxygen and the increase of carbon dioxide in the worst ventilated and crowded places is not very large, and is in any event far below the threshold of harmful physiological effects. Nevertheless it appears from the report of Peclet on the construction of a prison in Paris—a work that probably gave the first stimulus to the scientific treatment of the ventilation problem—that as early as 1843 to 1845 the carbon dioxide content of the air had been used as a measure for the efficiency of ventilation. Von Pettenkofer[6] in 1862–63, while demonstrating that the symptoms produced in crowded, ill-ventilated places were due neither to excess of carbon dioxide nor to deficiency of oxygen, nevertheless emphasized the doctrine still held by our sanitary engineers, that the percentage of carbon dioxide is a guide to the other deleterious properties of the atmosphere. A score of experiments lasting up to our own time has now just about eliminated the carbon dioxide and oxygen factors from the question.

---

[3] Weisman, Charles, "Biochemical Studies of Expired Air in Relation to Ventilation," Columbia University Dissertation, New York, 1913. (Excellent bibliography and review of literature. Only references not included in Weisman's study will be cited here.)

[4] Lee, Frederic S., "Laboratory Experiments with Air," *Journal of American Medical Association*, Nov. 7, 1914, **63**, 1625–8. (Short bibliography.)

[5] Quoted from Weisman.

THE ORGANIC POISON THEORY

This brings us to the third great theory that attempts to account for the ill effects of bad ventilation. As early as 1808 we find a reference to the elusive "organic poison" many investigators have tried to isolate. At that time Robertson wrote:[7] " 'Dr. Guthrie found that the moisture frozen on the insides of the windows of Petersburgh, during the winter, is highly volatile; and on being thawed, it gives out a gas equally pernicious, and in other respects possessing similar properties to those of carbonic acid gas.' " Experiments during the latter half of the nineteenth century sometimes substantiated the organic poison theory, and sometimes contradicted it. The work of the most famous supporters of the theory, Brown-Sequard and D'Arsonval (1887), has inspired many later investigators to attack the problem. The decisive results of Hill,[8] D. R. Lucas,[9] and Charles Weisman, working independently in 1913, have made the organic poison theory appear exceedingly improbable.

THE HEAT AND HUMIDITY THEORY

The chemical theories of ventilation effects have now been replaced by a physical theory, first suggested by Hermans (1883),

[6] Von Pettenkofer, M., *Liebig's Annalen*, 1862–1863, Suppl. Vol. 2, 1.

[7] Quoted from Weisman.

[8] Hill, Flack, McIntosh, Rowlands and Walker, "The Influence of the Atmosphere on our Health and Comfort in Confined and Crowded Places," *Smithsonian Misc. Collections*, 1913, 60, No. 23.

[9] Lucas, D. R., "Investigation on Proteid Substances in Respired Air," Report of the Committee on School Inquiry, New York City, 1911–1913, 3, 670–688.

who, observing the rise of his temperature in crowded places, and the discomfort that some subjects felt on entering an experimental chamber that had just been used, attributed these effects to the inability of the body to cool itself because of the surrounding elevated temperature and humidity.

Before proceeding with this review of ventilation literature, it might be well to explain further this physical theory, and also the concept of "relative humidity." The living body produces a certain amount of heat, giving off the excess to the surrounding atmosphere through radiation, convection, conduction through the clothing, and evaporation from the surface of the lungs and skin. If the surrounding air is too moist, evaporation can not go on. The amount of moisture which will prevent sufficient evaporation to cool the body is not, however, a question of the absolute amount of moisture in the air at any particular temperature, but of the relative humidity for that temperature. There is for every temperature a saturation point; when that is reached the air cannot take up any more moisture, and any superabundance of moisture will be precipitated. The relative humidity of the air at any particular temperature is the amount of water vapor that the air actually does contain, in proportion to what it would hold if it were completely saturated. As the percentage of saturation for air of a certain temperature becomes higher, the capacity of that air for absorbing more moisture from the skin and lungs becomes less. Conversely, when the air is but little saturated, it has a positive avidity for moisture, taking it from the skin, the membranes of the nose and throat, the eyes, etc.[10]

Continuing our survey of the ventilation experiments, we find that the general reaction of the human organism to moist air has been rather thoroughly studied by physiologists and hygienists. Lehmann and Jessen, in their work of 1890, pointed out that the physical factors of high temperature, high humidity and air motion play just as important a part as the composition of the air.

Rübner and von Lewaschew[11] (1897) contributed data on the relation between the moisture and temperature of the air, the elimination of water and carbon dioxide from the body, and the adaptability of man to high and low temperatures.

[10] Relative humidity is determined in engineering practice by the relation between the readings of the wet-bulb and the dry-bulb or ordinary type of thermometer. In the wet-bulb thermometer, the bulb is covered with thin muslin or silk, soaked in pure water. The evaporation of the water cools the bulb. The position of the mercury on such an instrument depends on the temperature of the air and on the amount of evaporation of water from the bulb cover, which varies inversely with the amount of moisture already in the air.

[11] *Archiv. f. Hyg.*, 1897, 29, 1.

The Oxford school—Handane,[12] Smith, Pembrey, Collis, Boycott, Cadman—have reported (1905–1911) observations made not only in the laboratory but also in cotton-weaving sheds, where the air is artificially humidified with steam, and in mines, where the temperature and humidity are notoriously high.

The Breslau school,—Flügge, Heymann, Paul, Ercklentz—reported in 1905 investigations on human beings, some in good health and others in various pathological conditions, confined in a 3 cu. meter glass experimental chamber under varying conditions of temperature, moisture and humidity. These experimenters also used psychological tests in studying the ventilation conditions. Paul conducted an experiment in a school-room in which fifty or sixty children were kept continuously for two or three hours, at a temperature below 19° C. (about 66° F.) and a humidity not exceeding 50 per cent. No unpleasant symptoms occurred with either teacher or children, in spite of the decided increase in the gaseous products of respiration, and no fatigue as shown by computation tests could be detected. In a series of chamber-tests, Paul found that as a result of confinement for three to four hours, though the carbon dioxide content rose to 10–15 parts in 10,000 (the normal is 4 parts in 10,000) the subjects did not experience any ill effects when the temperature and humidity were kept low. Psychological observations of æsthesiometer, tonometer, ergograph, completion-test and computation performances also showed normal under these conditions. With, however, a chamber-temperature of 26° C. (about 79° F.), 50 per cent. humidity, and with a temperature of 24° C. (about 75° F.), 75 per cent. humidity, the subjects felt headache, depression, etc., and, even before these subjective phenomena, showed increased body temperature as an objective effect. When the air of the chamber was set in motion (thus permitting the body to cool), without altering the chemical composition of the air, the physiological disturbances were immediately removed. When a subject breathed the fresh outside air by keeping his head outside the chamber, or inspiring through a tube coming from outside the chamber, he felt no relief of discomfort. On the other hand, if the body of the subject was placed outside the chamber, no discomfort was observed when the vitiated air of the chamber was inhaled through a tube, though the odor was annoying.

Ercklentz performed similar experiments on diseased persons, finding them more or less sensitive than normal individuals at the same temperature and humidity, according to the character of the disease.

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[12] Haldane, *Journal Hyg.*, 1905, **5**, 494. Haldane, Pembrey, Collis, Boycott and Cadman, Rep. Dept. Com. on Humidity and Ventilation in Cotton Weaving Sheds, London, 1909 and 1911.

Benedict and Milner (1907) reporting the results of an experiment on the metabolism of matter and energy in the human body, found incidentally that persons could remain for days in a stagnant atmosphere if the air was kept cool and dry.

The later experiments of Hill and his co-workers[13] (1913) corroborate the depressing effect of warm, moist conditions. To quote Hill's description:

"In one class of experiments we shut within the chamber seven or eight students for about half an hour and observed the effect of the confined atmosphere upon them. We kept them therein until the CO_2 reached 3 to 4 per cent. (300 to 400 parts in 10,000) and the oxygen had fallen to from 17 to 16 per cent. The wet-bulb temperature rose meanwhile to about 80 to 85 degrees F. and the dry-bulb a degree or two higher. The students went in chatting and laughing, but by and by as the temperature rose they ceased to talk and their faces became flushed and moist. We have watched them trying to light a cigarette (to relieve the monotony of the experiment) and puzzled by their matches going out, borrowing another, only in vain. They had not sensed the percentage of the diminution of oxygen, which fell below 17. Their breathing was slightly deepened by the high percentage of CO_2, but no headache occurred in any of them from the short exposure to from 3 to 4 per cent. CO_2. Their discomfort was relieved to an astonishing extent by putting on the electric fans placed in the roof. Whilst the air was kept stirred the students were not affected by the oppressive atmosphere. They begged for the fans to be put on when they were cut off. The same old stale air containing 3 to 4 per cent. CO_2 and 16 to 17 per cent. oxygen was whirled, but the movement of the air gave complete relief, because the air was 80 to 85 degrees F. (wet bulb) while the air enmeshed in their clothes in contact with their skin was 98 to 99 degrees F. (wet bulb). . . . One student breathed the air from outside the chamber through a tube and felt little relief. L. H. standing outside, breathed the air in the chamber through a tube, and felt no discomfort; the only result therefrom was a deepening of the respiration."

A series of studies of ventilation problems in which psychological tests were used, not incidentally, but as an integral part of the experiment, is the previous work done under the direction of Professor Thorndike.[14] Briefly considered this work was as follows:

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[13] Hill, Flack, McIntosh, Rowlands and Walker, "The Influence of the Atmosphere on Our Health and Comfort in Confined and Crowded Places," *Smithsonian Misc. Collections*, **60**, No. 23, 1913.

[14] "Ventilation in Relation to Mental Work," ed. by E. L. Thorndike, *Teachers College, Columbia University, N. Y. Contributions to Education, 1916.*

I. *The Effect of Conditions of the Air on Mental Work, the Condition Being Changed Daily* (Thorndike and Chapman).

The following air conditions were studied:

- (*a*) No fans, no outside air supplied, relative humidity 80 per cent., temperature 86° F. (30° C.).
- (*b*) Four fans, 45 cu. ft. per minute per person.
  - (*b*) Four fans at high speed, no outside air supplied, relative humidity 80 per cent., temperature 86° F. (30° C.).
- (*c*) No fans, 45 cu. ft. per person per minute of outside air, relative humidity 86 per cent., temperature 86° F. (30° C.).
- (*d*) No fans, no outside air supplied, relative humidity 50 per cent., temperature 86° F. (30° C.).
- (*e*) No fans, 45 cu. ft. per person per minute of outside air, relative humidity 50 per cent., temperature 68° F. (20° C.).

Four men were tested each week during each of five weeks. Besides registering their opinion as to the air condition by the same scale used in the humidity experiment (cf. p. 35), they were tested with the color-naming test, cancellation of 2's and 3's, hard opposites, addition, mental multiplication of a three-place by a three-place number and typewriting. The experimenters concluded that when a person exerts himself, his achievement is as good under the worst of the above listed conditions as under the best of them.

II. *The Effect of Conditions of the Air upon the Rate of Improvement of Mental Functions* (Thorndike and McCall).

The physical conditions were as listed above, except that each condition lasted one week, and each subject spent one five-day period under a good and one five-day period under a bad condition. Fifteen men were tested with the same tests as in I (except color-naming and opposites) and the experimenters concluded that the temporary efficiency of the work was as good in the worst as in the best conditions, when each condition was maintained four hours daily during the five successive days, and that the improvement made during the work of a bad-condition week was equal to the improvement during the best-condition week.

III. *The Effect of Conditions of the Air upon the Accuracy of Judgment* (Thorndike and McCall).

In experiments I and II the subjects worked presumably with maximum effort, the incentive being their fixed daily wage, the instructions of the experimenter and competition among the subjects. Not only did they have a general notion of how well they were doing in such tests, but each day they were given the scores made on the previous day. In experiment III the nature of the experimental situation did not stimulate effort, but positively encouraged carelessness. Four men were observed during six consecutive days for seven hours a day. The following air conditions were studied:

(*a*) 68° F. (20° C.), 50 per cent., 45 cu. ft., no fans.
(*b*) 86° F. (30° C.), 80 per cent., no air, no fans.
(*c*) 68° F., 50 per cent., 45 cu. ft., no fans.
(*d*) 86° F., 80 per cent., 45 cu. ft., no fans.
(*e*) 75° F. (about 24° C.), 50 per cent., 45 cu. ft., no fans.
(*f*) 86° F., 80 per cent., no air, five fans.

In the "no air" conditions the carbon dioxide rose to 40 parts in 10,000. The psychological work consisted in assigning values to specimens of handwriting and English composition of wide quality range, according to the Thorndike and Hillegas scales. The accuracy of each subject's work was obtained by comparing each rating of a specimen with the known value of that specimen previously obtained by having a great many persons grade the specimens, and averaging their grades for each specimen. The work was monotonous in itself, and barren of interest since the subjects were never given any means of telling how well they were doing. There was no practice effect, or if there was any, it was upset by growing boredom and carelessness. The experimenters concluded that an individual might make very much larger errors at one period than at another, but that the hot, humid, stagnant periods showed no larger errors than the cool, fresh periods. There was no demonstrable effect of heat or carbon dioxide content unless possibly the subjects tended under unfavorable conditions to use more of the period for the work and less for rest, *i. e.*, to use time for frequent brief intermissions in the course of the work, rather than for one long intermission at the close.

IV. *The Effect of Certain Conditions of the Air upon the Choice of Alternatives to Mental Work* (Thorndike and McCall).

The quantity and quality of certain mental products were measured when the subjects were left to their own choice as to how much work they should do.

The physical conditions studied were:

(*a*) 68° F. (20° C.), 50 per cent., sometimes with 30 cu. ft. of outside air, sometimes with no air.
(*b*) 75° F. (about 24° C.), 50 per cent., sometimes with 30 cu. ft. of outside air, sometimes with no air.

The conditions were changed every half day or every three days.

The options were:

For one hour and five minutes,
1. Mental multiplication for small pay.
2. Reading a current novel.
3. Resting.
4. Sleeping.

For one hour and five minutes.
1. Learning to typewrite.
2. Conversing.
3. Doing nothing.
4. Sleeping.

A maximal effort test in addition was also given. As far as the measurements themselves go, the experimenters concluded that heat (1) did not seem to have any effect upon the addition at maximal effort, (2) seemed to lead to the choice of the difficult mental multiplication over reading, rest or sleep, and (3) seemed to lead to the choice of conversation, rest, or sleep over the typewriting. The last occurred only when the 75° and 68° conditions were contrasted on the same day. As the experimenters point out, if the results of this experiment be combined with the results from certain other experiments, the influence of 75° as compared with 68° upon the choice between the work in question and light reading, conversation, rest, or sleep was nil. It is possible to argue from the results that the 75° condition is favorable to the non-muscular mental multiplication, and unfavorable to the more muscular work of typewriting.

Besides the laboratory experiments already reported several studies of psychological interest have been made of the effects of school-room ventilation. One of the earliest of these was made by Bass[15] who experimented with an elementary class in an ordinary fan-ventilated room and a class of approximately equal mental ability in a room submitted to recirculated air and ozone (to mask the odor). Each group was observed for two weeks. Physiological observations were made of body temperature and blood pressure, and psychological observations of division, substitution and ergometer performances. Neither physiological nor psychological measurements showed any reliable difference in the effect of the two air conditions. The psychological results were particularly difficult to interpret because of the large practice effect, yet careful statistical treatment of the data showed no inferiority of the "recirculated air" group in total amount of work done, rate of improvement or rate of fatigue. A second experiment[16] in which much better records were kept of the actual physical conditions of the rooms resulted in the same absence of significant differences in weight and chest measurements, and in division, substitution and cancellation performances. Since both these experiments were performed with classes whose make-up was not under the control of the experimenters, the results were further obscured by some initial difference in the ability of the test and the control class. This disadvantage was removed and more extensive measurements made in a further research[17] under the direction of the New York State Commission on Ventilation, also concerned with the effects of "fresh" outside and of "recirculated" washed air. The purpose of the experiment was to measure the difference, if any, in the school achievement and rate of learning of school pupils submitted to these two air variables. Eighty-eight pupils who were to begin the work of the sixth grade were tested (September, 1915) with arithmetic, association, visual vocabulary, reading, trabue completion and selection tests. On the basis of these tests they were divided into two groups of the same ability. One of the groups thus formed (F) was subjected to outside ventilation from the time heat was first provided until the close of the term. The other group (R) was subjected to ventilation by recirculation, plus occasional use of outside air, throughout the same period. The teaching was the same for both groups, two teachers dividing the work by subjects taught. The F group was in Room 1 until December and from then on in Room 2; the R group was in Room 2 until December and from then on in Room 1. All measurements were made by the same person, on the same day, under as nearly the same conditions as possible, for both groups. These measurements comprised:

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[15] Bass, "Experiment in School Room Ventilation With Reduced Air Supply Through Individual Ducts," *Trans. Amer. Soc. Heat. and Vent. Engineers*, 1913, 19, 328.

1. Tests of learning or practice experiments in addition, cancellation of letters and digits, finding addresses.
2. The achievement in the regular school work as measured by the regular school examinations planned, given and scored by the teacher. The marks given for September before any ventilation conditions were introduced proved that at the start the F and R groups were in the opinion of the teachers of approximately equal proficiency.

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[16] Bass, "The Recirculating of Air in a Schoolroom in Minneapolis," *Trans. Amer. Soc. Heat. and Vent. Engineers*, 1915, 21, 109. Also Ms. on file with N. Y. State Commission on Ventilation under whose auspices the work was done.

[17] Thorndike, Ruger, McCall, "The Effects of Outside Air and Recirculated Air upon the Intellectual Achievement and Improvement of School Pupils," *School and Society*, 1916, 3, 679.

3. The six tests used to divide the entire group into two halves of equal intellectual ability repeated at the end of January with material of the same scope and plan and approximate degree of difficulty but different content in detail.
4. Nine other standard tests in arithmetic, spelling, reading and logical acuity given at the beginning and at the end of the experiment.

As a result of these measurements it appeared that the use of recirculated air does not impair the ability or readiness of pupils to learn. In fact measures 1 to 4 resulted in a slight superiority of the R group, although the unreliability of this difference was large. The experiment is being repeated, but in so far as this single experiment may be accepted as the best present evidence, the intellectual progress of children seems not to be impaired by an increase of CO_2 from 8 to 10 parts in 10,000 or by recirculation of washed air to an extent that diminishes the steam consumption by 50 per cent.

In most of the ventilation studies reported in the literature, the humidity factor has not been studied independently. When, moreover, moisture has been taken into account it was always high humidity combined with high heat. So although we now have a considerable amount of data in regard to the effect of excessive moisture, we have very little about the effect of excessive dryness. To get the atmosphere as dry as possible was one of the prime objects with the older writers on heating and ventilating. That the world had recovered from its ancient fear of atmospheric dampness by 1838 is shown by the fact that the British House of Commons was equipped with humidifying apparatus in that year. Since that time, ventilating engineers have become increasingly interested in installing such apparatus, though the profession admits that it has no adequate basis of information as to what specific conditions are most desirable.[18] A search of the medical, psychological and technical literature reveals little real knowledge on the subject. A number of articles seem to indicate that there is some justification for the belief that low relative humidity is undesirable from the point of view of the healthy condition of the membranes of the nose and throat. That is, however, a medical problem that need not concern us here. It is in the field of behavior that one gets the most extravagant statements about the effect of dryness in producing nervousness, irritability, and general inefficiency. This is in the domain of psychology itself; such effects of dryness, if they exist in the extreme form in which they are reported to occur, should be demonstrable by means of psychological tests. That the effects are thought to be severe and easily discoverable to the most casual observer is shown by the following quotations.

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[18] Cf. Lyle, J. J., "Relative Humidity, Its Effect on Comfort and Health," *Transactions Amer. Soc. Heat. and Vent. Engineers*, 1912, 106.

Watt,[19] who is particularly concerned about the matter, says:

"Insanity grows on those who live in hot dry air, do exasperating work, and feel abused. . . . Our country throngs with nervous wrecks. As we progress in wealth and culture the thing becomes more prevalent. Men are breaking down in business by too much attention to it, they think. The real trouble is they are conducting their business in dry hot rooms during the cold months of the year. There they become so weakened that the right air of the warm months does not revive them. . . . The area on earth where the divorce evil is greatest and where the children have least respect for their parents is probably the northern part of the United States, where we have hot dry air in our homes, offices, schools and public places about two-thirds of the year. It makes men and women hanker for something they have not. They are impatient with everything about them, thinking the fault is in the people and in institutions rather than in the atmosphere. . . . Children are especially ungrateful to their parents when kept in these drying kilns which our homes resemble and outdo in their deathly dryness. . . ."

Similar statements are to be found in his chapters on "American dry rot," the "steam-heated woman" and dryness as a cause of the falling-off of church attendance.

In a shorter article,[20] he writes of the effects of humidifying the air with a jet of steam in these terms:

"We avoid hundreds of headaches, we cure stupidity, we permit clearness of thought; we have cut down the number of cases of office discipline more than 75 per cent. since we turned on the steam."

Goldsbury[21] expresses the common opinion about outdoor humidity when he says:

"Later, in moving from the Central West to a dry northern state, I found the atmosphere trying. The skin often had a parched feeling, and the dryness of the lips was a constant annoyance. This effect was so marked that after four years I felt that I must get away to a moister climate. I had a sense of nervous tension and dreaded passing another winter in the state. Early in December came my opportunity to move away, and on my journey westward I spent a day in Chicago. As I walked along the lake front the 'feel' of the cold, wet air, raw though it was, was one of the most refreshing sensations I ever experienced. I then realized that the improvement I had felt throughout the day was due to the presence of an increase of moisture in the air."

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[19] Watt, Wm. E., "Open Air: A Statement of what is being done and what should be done to secure right air in homes, schools, offices, factories, churches, etc.," The Little Chronicle Co., Chicago, 1910.

[20] Watt, Wm. E., "Humidity and Scholarship in School," *American Physical Education Review*, Nov., 1910, 600.

[21] Goldsbury, P. W., "Humidity and Health," *Boston Medical and Surgical Journal*, Sept. 7, 1911, **165**, No. 10, 366–372.

Smith[22] reports the general opinion in regard to indoor humidity thus:

"Moreover, properly moistened indoor atmosphere lacks all the oppressive dry feeling so characteristic of the average artificially heated room, seeming more like the corridor of a well-ventilated hotel. The quieting effect of such an atmosphere is striking. There is an indescribable sense of relaxation and poise, contrasting strongly with the feeling of nervous tension so frequently experienced in overheated dry rooms."

Referring to some experiments conducted by himself, Smith says:

"It was satisfactorily proven that one may live during the coldest weather in a room of 65 degrees F. where the relative humidity is kept at about 60 per cent. During the experiments upon the sensations produced by different percentages of saturation, and in order to obtain the opinions of persons having no knowledge of the existing conditions, one room was equipped with a moistening apparatus and the temperature kept at 65–68 degrees with a relative humidity of about 60 per cent. An adjoining room, without a moistening apparatus and heated by an ordinary steam radiator, had an average temperature of 72–74 degrees, with a relative humidity of 30 per cent. In every instance and without at all knowing what the temperatures were in the two rooms, the opinion was unhesitatingly expressed that the first room was several degrees warmer than the second. . . . The relative humidity is the balance wheel that regulates our comfort at different temperatures in still air. . . . Generally speaking, dry air is an excitant, often causing sleeplessness and irritability accompanied by a drier skin and quickened pulse. Moist air is more of a depressant, producing quiet sleep and slower circulation of the blood."

In the minds of numerous other writers for the technical journals there is no doubt of the effect of dry air in producing nervousness. At least one attempt previous to this one has been made to determine experimentally what is the difference in the effect of moist and dry air. The experiment was conducted at a school in Boston[23] by means of an appropriation set aside by the Schoolhouse Commissioners acting with the School Committee. The experiment covered about three months. One of its objects was "to find whether the mental and physical conditions of the occupants of a school are improved by increasing the relative humidity of the air in the rooms." The classes were so arranged that corresponding grades of pupils occupied similar rooms in each half of the building. "Several classes at one end of a floor were subjected to moist atmosphere and classes at the other end to naturally dry air." As Dr. Harrington, under whose jurisdiction the experiment was conducted, says in a personal letter, "pupils tested in the respective grades corresponded in mentality, physique, and social status with pupils in corresponding grades, *e. g.*, fourth grade pupils in a room located in half of the building submitted to humidification, were compared in mentality, etc., with children in the fourth grade in rooms situated on the side that was not submitted to humidifying conditions. This same plan was followed through all grades. The test given to the children in each grade was the same for pupils in that grade in rooms on both sides of the building. These tests were given at the same hour of the day, and on the same date." Thirty cubic feet of air per minute per occupant was supplied. A record of both the physical condition of the children and the percentage of attendance seemed to show no difference. The experimenters concluded that "on the basis of similar mental tests conducted on both the moist and dry sides of the building, no appreciable difference was found."

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[22] Smith, Henry M., "Indoor Humidity," *American Gas Light Journal*, Feb. 27, Mar. 20, Mar. 27, 1905, esp. 490–91.

CLIMATE

Our summary of the literature relating to the effect of air conditions upon man would not be complete without some reference to the great problem of the influence of climate. The lay opinion that climate has distinct effects upon the health and working ability of man, and that racial characteristics are closely correlated with climate, has been a favorite thesis with many writers. We find speculations on the subject in the works of Hippocrates, Aristotle, Montesquieu, Voltaire, Buffon, Hume, Buckle and Disturnelle. Rätzel in his "Anthropogeographie" gives an outline of the earliest views concerning the effect of climate. From this we see that many things—from the color of man's skin and the contour of his face, to the prevalence of religious ideas and the (supposed) fact that more twins are born in Egypt than elsewhere—have been explained as an effect of climate. That the humidity factor has been accredited with considerable importance is shown by this statement from Russell.[24] "The quick increase of the temperature of the air and the dryness and sunshine of the spring have the effect of precipitating mental alienation and increasing nerve instability; the organism is least robust when the winter passes away." In recent years we have been getting away from those generalizations about the differences between Northerners and Southerners, the climatic reason for the grimness of the Scot, the reason for our inability to work on certain kinds of days, and so on, and have begun some really scientific studies of the factors involved. Among the most promising of these have been a number of investigations of the working ability of the white man in the tropics. Discussions from the medical and psychological point of view are those by Hellpach[25] and by Berliner.[26]

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[23] Eveleth, Charles F., "Experiments on Humidifying Air at the Oliver Wendell Holmes School," *Trans. Amer. Society Heating and Ventilating Engineers*, 1913, 109–127. Also *Heat. and Ventilating Magazine*, Oct., 1913, 10, No. 10, 14–19.

The beginnings of measurements along the line of the effect of atmospheric conditions were made by Malling-Hansen and by Hösch-Ernst in their study of growth rhythms. Seasonal variations in appetite were observed by Schuyten[27] and by Binet."[28] An extension of the physiological investigations was made by Schuyten and by Lobsien who included in his plan tests of attention and memory as well as tests of muscular strength.

A more elaborate investigation is that of Lehmann and Pedersen[29] who attempted an analysis of the influence of the specific factors in the atmospheric environment, by means of long series of tests in 1904–06. Through weekly tests of about 80 boys 10–14 years of age and daily tests of a smaller number during the greater part of a year they studied the effect of the intensity of the sun's rays, temperature and air pressure upon ergographic performance. With other subjects they conducted experiments in addition and memory for nonsense syllables and upon themselves daily dynamometer tests. Their conclusions, based on careful statistical treatment of their data, are as follows:

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[24] Russell, Francis, A. R., "The Atmosphere in Relation to Human Life and Health," *Smithsonian Misc. Collections*, 1896, 1072.

[25] Hellpach, Willy, "Die Geopsychische Erscheinungen Wetter, Klima und Landschaft in ihren Einfluss auf das Seelenleben dargestellt," Leipzig, 1911.

[26] Berliner, B., "Der Einfluss von Klima, Wetter und Jahreszeit auf das Nerven und Seelenleben," *Grenzfragen des Nerven und Seelenlebens*, 1914, **5**.

[27] *Paedolog. Jahrb.*, 1908.

[28] "La consommation du pain pendant une année scolaire," *L'année psycholog.*, 1897, **4**, 337.

[29] Lehmann, Alfred und Pedersen, R. H., "Das Wetter und unsere Arbeit," *Archiv für die gesamte Psych.*, 1907, **10**, 1–104. (Resumé of previous work on seasonal variations.)

The actinic rays of the sun increase muscular strength in proportion to the strength of the rays. Heat has, on the other hand, a different optimum so that higher as well as lower temperatures have an unfavorable action on muscular strength. In January muscular strength begins to increase (despite the low temperature) with the increase in the strength of the light, and this rise continues up to the high temperature of the summer months, June to August. When the temperature sinks in September, the rise of muscular strength begins again. At the end of November, on account of the small light strength, and the low temperature, a standstill or a decrease is noticeable. The muscular strength is in spring directly correlated with the atmospheric pressure, but in the fall seems to be independent of this. A sudden change to a place of lower pressure has no effect upon muscular strength, but the return to a normal pressure causes an increase in strength, which is larger or smaller according to the temperature conditions. Speed in addition is not influenced by changes in atmospheric pressure, but is dependent upon temperature, increasing when the temperature nears an optimum (which is different for different individuals) and decreasing when it leaves this optimum. This optimum is far lower than the optimum for muscular strength. Addition is thus in every way distinguished from the central processes which condition the strength of the grip. Meteorological conditions influence memory for nonsense syllables in the same manner in which they affect muscular strength.

Although this is the most extensive and on the whole the most scientific investigation of the effect of atmospheric conditions upon both muscular and mental work one cannot agree with the explanation of some of the findings. The authors consider that memory for nonsense syllables and addition represent rather dissimilar mental functions, the former being dependent upon the strength of attention, the latter upon the fineness of the psycho-physical organization that has taken place. Their experimental results and also the low correlation between memory and addition which they report lend some support to their theory. Nevertheless as an explanation of the organization of mental activity their mysterious association of memory and muscular strength as "Kraftleistungen" is bound to remain very unconvincing.

Dexter[30] made an empirical study of the mental and physiological effects of meteorological conditions, as revealed in statistics of attendance in certain public schools in New York City during the years 1895–96, deportment of school children in Denver, Colorado, assault and battery arrests in New York City, 1891–97, murders in Denver, 1884–96, discipline in New York City Penitentiary, 1891–97, arrests of the violently insane in New York City, 1891–97, attendance at out-patient department of Roosevelt Hospital, 1893–94, days off duty (supposedly for sickness) of New York City policemen, 1891–95, deaths in New York City, 1886–97, suicides in New York City, 1882–87, arrests for drunkenness in New York City, 1893–95, clerical errors in national banks in New York City, 1896–97. A questionnaire answered by 86 teachers in charge of over 10,000 pupils also furnished some information as to the kind of weather in which the children did their best mental and mechanical work. These teachers reported that in a climate similar to that of New York City, calm, cold and clear days gave the best results and hot, muggy days the worst results.

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[30] Dexter, Edwin G., "Conduct and the Weather," *Psychological Review, Monograph Supplement*, No. 10, 1899. "Weather Influences," New York, Macmillan, 1904.

All the conclusions from the statistical study are based on a comparison of "expectancy" with "occurrence" curves; for example, if a certain percentage of all the days considered lay within a certain five-degree zone of temperature, then that same percentage of a particular crime under consideration should occur on days within that five-degree zone, provided that temperature had no effect. If, however, temperature had an influence it would show out as an excess or deficiency of cases compared with the expected percentage for that particular temperature. The results of the study can be summed up in the following table:

Dexter's conclusions and final explanation of his results are expressed in the statements on page 18.

1. Varying meteorological conditions affect directly, though in different ways, the metabolism of life. (By metabolism of life is meant the process of oxidization of body tissues.) Some weather conditions accelerate the vital processes and others retard them. High temperatures, high winds, (better ventilation), fair days and low humidities have an accelerating effect; in their extreme form they produce too rapid a metabolism to be borne by the depleted organism. On the other hand, low temperatures, calms, high pressures, moist and cloudy days have a retarding effect; in their extreme form they so lessen the production of available energy as to reduce its quantity below the minimum required for life or health; under both extremes we find increased sickness and a high death rate.

2. The reserve energy capable of being utilized for intellectual processes, and activities other than those of the vital organs, is affected most by meteorological changes. The reserve energy is the excess energy not used up in the vegetative processes and so

TABLE SHOWING THE EFFECTS OF METEOROLOGICAL CONDITIONS AS FOUND BY DEXTER

Drawn up from Charts

+ means excess of occurrence over expectancy.
− means deficiency of occurrence compared with expectancy.

	Temperature			*Barometer*			*Humidity*			*Wind*			*Character of Day*			
Data	*Low*	*Med.*	*High*	*Low*	*Med.*	*High*	*Low*	*Med.*	*High*	*Low*	*Med.*	*High*	*Fair*	*Cloudy*	*Wet*	*Dry*
School Attendance (Absences) . .	Worst	Best			Best			Best			Best		Best			Best
School Deportment (N. Y. C.) . .	−	+	−	+		−	+		−	−	+	−		−	−	
School Deportment (Denver) . . .	+	−	+	+	−	+	+		−	−		+	+	−	−	
Assault (N. Y. C.)	−		+	+	−	−	+		−	−	+	−		−	−	
Murders (Denver)	−		+	+		−	+			−		+		+	+	
Disorder in Penitetiary	+	−	+	+		−	+		−				+			+
Drunkenness	+		−			+	−		+	−		+	+			+
Insanity	+	−	+	+		−	+		−	−		+	+			+
Policemen off Duty (sickness) . . .	+		−	+	−	+	−	+	−	+	−	+		+	+	
Suicide	+	−	+	−	+	−	+		+	−	+	+	+			+
Hospital Patients (sickness)	+	−	+	+	−	+	−		+	+	−	+		+	+	
Deaths	−		+		no data		−		+	+	−	+	+			+
Clerical Errors	−		+	−	+		+	−	+			−		+	+	

made available for action and for intellectual processes. This reserve energy is subject to a rhythm of exhilaration and depression. There is increased reserve energy under the accelerating weather conditions. Although high temperatures favor metabolism, exceedingly high temperatures cause a vital demand exceeding the production, as is shown by the great increase in deaths and the sudden decrease in assaults for the highest temperatures.

3. The quality of the emotional state is plainly influenced by the weather states.

4. The weather effects upon the reserve energy available for action are of the greatest importance. The hot, humid, cloudy wet days, although making us feel out of sorts and liable to be troublesome, show the least numbers of misdemeanors, owing to the fact that the energy required to carry out the emotion is lacking because of the depleting effect of the weather.

5. Those meteorological conditions which are productive of misconduct in a broad sense of the word, are also productive of health and mental alertness; misconduct is the result of excess reserve energy not directed to some useful purpose.

The part of this work which is of particular interest to us in our consideration of the problem of humidity is the fact that with the classes of disorders considered, low humidity is always associated with that restlessness and nervousness that leads to midsconduct. A glance at the table shows an excess of all forms of active disorder under low humidity, and an excess of sickness, drunkenness, death, and clerical errors at the high humidities. Although Dexter points out the possibility that this may be due to electrical phenomena, he nevertheless feels that dryness in itself is accompanied by excesses in conduct which are indicative of peculiarly unbalanced emotions. He asks the question which is very pertinent to our ventilation study: "If such be true for our out-of-door conditions, why not for indoor? How much of our instability of temper is due to furnace heat and a crackling air?"

It is impossible to give an adequate presentation of this piece of work without showing at the same time the charts upon which the conclusions are based. Nor is it quite fair to group the results as has been done in our table, since a shift of a few meteorological groups will make the middle region begin and end at different places, and often reverse the meaning of the phenomenon under discussion. Because of this possibility of confusing the boundaries of the low middle and high regions one can often put upon a chart a construction that does not agree with Dexter's interpretation of the same facts. In any event the excesses or deficiencies over the normal occurrence are small. Without a knowledge of the probable errors it is impossible to tell how significant the differences are, though in many cases they do not seem reliable. This is especially true of curves that waver above and below the normal occurrence line as they pass through the low, medium and high groups, or show distinct sex differences.

Even if we were to grant that the study shows unmistakable effects of various meteorological conditions upon behavior, we should be very cautious about accepting Dexter's conception of the underlying physiological causes. His theory of accelerating and depressing effects, his doctrine of the reserve energy, his blanket explanation of misconduct, nervousness, health and mental alertness are sheer assumptions resulting from the necessity of interpreting the data. We question also the assumption that the number of patients treated in the clinic bears an inverse relation to the number of patients too ill to come out for treatment, and we are inclined to think the explanation of the depressing effect of calms as a ventilation phenomenon on the "deficiency of oxygen" and "superabundance of carbon dioxide" basis, has already been invalidated in the first part of this paper. It is probable that a good many of the phenomena could be less fantastically explained as a simple result of the relative number of people indoors and outdoors during various conditions and their reactions to mere deprivation of outdoor life and relaxation.

Another large-scale empirical study of the effect of climatic conditions is that of Ellsworth Huntington.[31] His general hypothesis is this: "To-day a certain peculiar type of climate prevails wherever civilization is high. In the past the same type seems to have prevailed wherever a great civilization arose. Therefore, such a climate seems to be a necessary condition of great progress." He formulated this hypothesis as the result of a study of the records of many thousands of workers, (1) factory operatives in the cities of New Haven, New Britain, and Bridgeport, Conn., and Pittsburgh, Pennsylvania; (2) operatives in southern cities from Virginia to Florida, and (3) students at the United States Naval Academy at Annapolis, and the Military Academy at West Point. He begins his argument with a chapter entitled "Race or Place," in which he contends, among other things, that the superior energy and initiative of northern peoples compared with southern can be demonstrated through the fact that northern farmers have cleared and improved a greater percentage of their holdings than have southern farmers. Confining our attention to one of his comparisons of white farmers (pp. 19–20) we find his data[32] to be as follows:

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[31] Huntington, Ellsworth, "Civilization and Climate," New Haven, Yale University Press, 1915.

	Northern	*Southern*
Average acreage per farm	92.5	133.4
Average acreage improved land	63.5	45.9
Per cent. of total land improved	69%	34%

It is a startling indictment of the southern climate, if the white man's efficiency has been so lowered; it would seem, however, that this conclusion cannot be drawn in view of the economic and social factors which might prevent the white Southerner from cultivating more of his much larger holdings. The matter of climatic effects is far too complicated to be settled by a simple comparison of percentages of land holdings improved, value of property or value of annual products. Nor will the question be brought any nearer to solution by collecting the opinions of persons who have immigrated to a climate different from that to which they or their ancestors have been accustomed. There is more promise in Huntington's quantitative studies, where the effect of climate in terms of actual accomplishment is noted, quite apart from the subjective effects that have long formed the basis of common opinion about weather influences. In Huntington's chapter "The Effect of the Seasons" he reports the results of an investigation of the daily work of pieceworkers in certain New England hardware factories, basing his curves on the average hourly wages of each group of operatives from 1910–13, making allowances for the number of employees and the length of time that they worked. All the figures were reduced to percentages, *i. e.*, if the maximum wage for a group of girls was twelve cents an hour, it was called 100 per cent., while if the maximum wage for a group of men was thirty cents, it also was called 100 per cent. This was done to give the variations in the wages of the girls and the men the same weight in the final computations. The curves obtained by plotting the work of the Connecticut operatives week by week were smoothed and corrected for practice. It appears, then, that all the curves show an extremely low place in mid-winter, and a less pronounced low place in midsummer, a high point in June, and a still higher point at the end of October. A series of curves representing the work of operatives engaged in making electrical apparatus in a factory in Pittsburgh 1910–13, resemble the Connecticut curves. Curves are also presented for the seasonal variations in the death rate in New York State, 1892–1906, for the increase in weight of tuberculosis patients at Saranac Lake, N. Y., 1893–1902, and for the work (1) of girls in a tobacco factory at Winston-Salem, N. C., (2) of operatives in cotton factories at Columbia, S. C., and Augusta, Georgia, (3) of carpenters at Jacksonville, Florida, and (4) of cigar makers at Jacksonville and Tampa, Florida.

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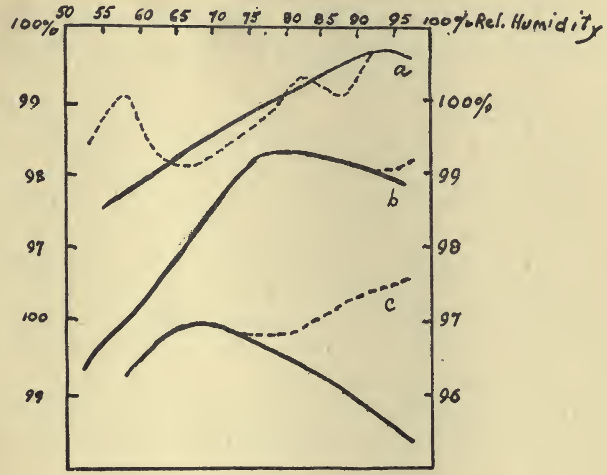
[32] Original data (not percentages) from U. S. Census, 1900.

From an analysis of all these classes of data, including the strength test measurements of Lehmann and Pedersen, Huntington shows that when the summers are particularly favorable and the winters unfavorable, the previously noted seasonal rhythm (maxima of efficiency in June and November) breaks down, and the June maximum and summer minimum disappear. If we go farther south to places where the winters are favorable and the summers very hot, we find a change in the opposite direction, for the summer minimum greatly increases and shoves the two maxima more and more into the winter until the two coalesce; that is, the summer inefficiency lasts for a much longer period and finally gives way to a single maximum in the winter. Because of the mildness of the winters the midwinter drop in efficiency does not take place; instead the curve gradually sinks to the summer level.

So far, Huntington has shown that health and physical activity vary with the seasons. The next problem is to inquire whether mental activity varies in the same way. For this Huntington uses the weekly averages in mathematics for the first-year class at Annapolis for the years 1907–13, the daily marks for the first-year class in English at Annapolis for the year 1912–13, and the daily marks in mathematics for a year and a half, for the classes entering West Point in 1909 and 1910. Measures were taken to eliminate the effect of holidays, examinations, and gradual raising of the faculty standard. From a consideration of these curves, one sees that mental activity resembles physical work in having the two main maxima, except that these two maxima are nearer together and displaced toward the winter. Huntington remarks that this agrees with Lehmann and Pedersen's findings in the case of the addition tests, which also showed the highest efficiency at a lower temperature than that which gave the best results in the strength tests.

In his chapter "The Effect of Humidity and Temperature," Huntington finds no discernible effect of light, in producing the variations of the curve of work. The extent to which people are shut up in their houses also has little influence. Temperature is the most important factor, and in southern New England, low temperature seems to be much more injurious than high. It is the matter of humidity, however, that chiefly concerns us. Huntington has no data on the effect of indoor humidity, but shares the common opinion that the dry air of our buildings during the winter has harmful effects, and is probably an important factor in causing the low efficiency of midwinter. In tracing the relation of work and humidity among factory operatives of Connecticut, he divides the year into (*a*) winter, (*b*) spring and fall, and (*c*) summer, averaging together in each part the work of all the days having a given humidity. Plotting percentages of relative humidity against percentages of efficiency of work (obtained as is explained on p. 21), he gets the following figure.



To quote Huntington's explanation of this figure:

"The heavy solid lines represent what I believe to be the true conditions when other disturbing elements are removed; while the dotted lines show the actual figures. In winter the dampest days are unmistakably the times of greater efficiency. We may shiver when the air is raw, but we work well. The reason is twofold. In general the temperature rises at times of excessive humidity, and this in itself is favorable. Moreover, the air, when taken into the house, does not need to be warmed so much as under other conditions, and thus it remains comparatively moist.

"In spring and fall, when the temperature ranges from freezing to 70° with an average of about 50° F., the best work is performed with a relative humidity of 75 per cent. In other words neither the dry nor the wet days are the best. The summer curve is the most complex of the three. It rises first to a maximum at 60 or 65 per cent., then falls, and once more rises to a higher maximum. The first maximum seems to be due to humidity, the second to temperature. A hot damp day is unquestionably debilitating. The majority of the dampest days in summer, however, are comparatively cool, for they accompany storms. The coolness counterbalances the humidity, and people's efficiency increases. Hence we disregard the right hand maximum and conclude that with an average temperature of 65° a relative humidity of about 60 per cent. is desirable.

"The most unmistakable feature of the curves as a whole is that they show a diminution of work in every way in dry weather. This evidently has a bearing on the low level of the curve of energy in winter. At that season the air in our houses ought to have a humidity of 60 or 65 per cent., but most of the time the figure is only 20 or 30. . . . Apparently this extreme aridity has a markedly debilitating effect."

The criticism of this argument must be that the writer has not justified his departure from the dotted figures which are his real data. If he is not permitted to smooth off the marked rise in winter efficiency at about 57 per cent. humidity, and in summer efficiency at 97 per cent. humidity, his case becomes very weak. It might be added that the reliability of his winter data at the high humidity end of the curve must be very small, as days of 95 per cent. and even of 85 per cent. relative humidity occur very seldom in an ordinarily cold northern winter.

In his chapter on "Work and Weather" Huntington considers the effect of changes of temperature from day to day. He sums the matter up for the Northern States as follows:

"Taking the year as a whole, uniformity of temperature causes low energy; a slight rise is beneficial, but a further rise is of no particular value; the beginning of a fall of temperature is harmful, but when the fall becomes a little larger it is much more stimulating than a rise; when it becomes extreme, however, its beneficial qualities begin to decline."

For the southern latitudes: "The outstanding point is that changes of temperature, provided they are not too great, are more stimulating than uniformity while a fall is more stimulating than a rise." In regard to the effect of the character of the day and its relation to storms, Huntington finds that on tracing efficiency through an average weather cycle such as generally occurs in the region of New England tested, people are usually less efficient on the clear days, moderately efficient on the partly cloudy days, and on the first cloudy day, and most efficient at the end of a storm.

In regard to all his work, Huntington himself admits that "the stimulus of the succession of clear and cloudy days amounts to only 1 per cent. . . . changes of temperature from day to day produce a variation of only a little over 2 per cent. . . . the maximum effect of humidity appears to be only 3 per cent. . . . the effect of the mean temperature upon the girls of Connecticut is 7 per cent. . . . the effect of the seasons reaches nearly 9 per cent. when four years are averaged and nearly 15 per cent. for individual years." As there is no means of finding out what is the reliability of these differences, one cannot say much about their significance. It seems unlikely, however, that any differences except those considered under temperature are real variations in efficiency. The chances are that even these are not to be attributed to temperature alone, but to the fact that temperature acts as the starting point for a whole series of factors in the complicated human situation, such as ill-health, bad housing, economic pressure, and so on, and probably intensifies all of them.

A further division under the general topic of Climate is the whole subject of open air vs. house air. Only the psychological aspects of the matter can here be considered. The problem of the supposed beneficial effects of open air and open window work is one that has agitated school authorities for some time as is shown by the history of the open air school movement.[33] Various attempts have been made to obtain experimental evidence on the question. Among the earliest of these was a study by Roach[34] of increase in weight and improvement in mental performance on the part of a third grade class in a cold-air room compared with a class in a warm room. The experiment, which has been very justly criticized by Whipple[35] on methodological grounds, showed that on the surface of things the fresh air class had the advantage. An extensive experiment still being carried on at the Horace Mann School, Teachers College, Columbia University, has given no justification (except in its first year[36]) for the belief that open air classes do superior mental work as measured by a variety of psychological tests. Recently Bliss[37] reported the results of an experiment with a second, a third, and a fifth grade class in open window rooms with corresponding control classes in well warmed and ventilated school rooms. All pupils were checked upon the matter of

1. Degree of nutrition, measured in terms of weight gained and weight lost.
2. General health, as indicated by the number of children absent because of illness and the total number of days lost thereby.

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[33] Upton, "Open Air Schools," *Teachers College Record*, 1914, **15**, No. 3.

[34] Roach, "Revitalizing Devitalized Children," *Amer. Jour. of Pub. Health*, 1913, **3**, No. 2, 13.

[35] Whipple, *Journal of Ed. Psych.*, June, 1913, **4**, 353.

[36] Keyes, "Effect of Outdoor and Indoor School Life on the Physical and Mental Condition of Children," Trans. of Fourth Internat. Congress of School Hygiene, Buffalo, 1913, **2**, 125.

[37] Bliss, "Open Window Classes," *Psychological Clinic*, April 15, 1915, **9**, 29.

3. Mental condition, indicated by the comparative amount of afternoon fatigue in the two classes (tested by checking A's and by arithmetic tests). Comparing the relative number of pounds in weight gained or lost, he found that the open window classes were in general in worse physical condition than the control classes though the number of individuals who gained or lost was distributed about equally between the two classes. The open window classes also had more cases of absence on account of colds, sore throat and contagious diseases. The psychological tests showed no difference in fatigue effect in the two groups. Both open window and control classes improved in cancelling A's in the afternoon and did less well in the addition test. Their curves are almost parallel. The psychological results are obscured by practice and by the unequal initial ability of the two groups, but the conclusion that there is no significant difference in the performance of the two groups is fairly enough drawn.

One comes away from reading the literature with little additional knowledge of what "good" air really is, and little evidence with which to bolster up a belief that "bad" air has a deleterious effect in the laboratory, the school-room or the work-shop of life. In view of the polemics of the fresh air question we shall not attempt any explanation or justification of negative results, but shall go on to a description of the experiment that is the subject of this monograph.

CHAPTER II

General Method of the Humidity Experiment

The experiment was carried on in the laboratory of the New York State Commission on Ventilation. A technical description of the equipment of the plant has been given elsewhere.[1] It will be sufficient for our purposes to say that there was an experimental chamber 10 feet by 14 feet by 10 feet high, and a control room elaborately fitted with heating and cooling devices and with apparatus for humidifying and for drying the air, so that any air condition met in practice could be reproduced, and the different factors of the air environment studied independently.

The experiment lasted from October, 1915, to the end of January, 1916. We had planned to have eight squads of four subjects each, but for various reasons only twenty-nine subjects were actually tested. Because of the unusually high outdoor humidity during the month of October, which made it impossible for the engineers to produce the requisite dryness of the air in the experimental chamber, that month's experiment was regarded as a preliminary study, and the results of the psychological tests for that time are not herein included. During the month of November a moderate degree of dryness was studied, and during December and January the more severe conditions were used.[2]

The squads were designated A to H in chronological order. We observed four subjects during a period of two weeks, the first week under 50 per cent. relative humidity, the second under 20 per cent. The subjects were in the experimental room five days a week from nine until five o'clock, with the exception of three ten-minute recess periods. After a fortnight another squad began under the 20 per cent. condition and spent its second week under the 50 per cent. humidity. This reversal of conditions was designed to equalize the practice effect. The work done by Squad A in its first (wet) week, plus the work done by Squad B in its second (wet) week was compared with the work done by Squad A in its second (dry) week, plus the work done by Squad B in its first (dry) week. The averages derived from these two totals gave a measure of the difference in the effect of the two conditions. We compared the effect of two wet weeks when one squad was at the beginning and the other at the height of its practice curve, with the effect of two dry weeks with practice similarly equalized.

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[1] Kimball, D. D., and Palmer, G. T., "Experimental Laboratory of the New York State Commission on Ventilation and Description of the First Year's Work," *Trans. Amer. Soc. Heat. & Vent. Eng.*, 1915, **21**, 135.

[2] For chronology and actual physical conditions see Appendix.

Each new squad came to the laboratory on the Saturday preceding its fortnight's work for instruction and preliminary practice. The experimenter gave each subject a typewritten set of instructions, a copy of which is printed in the Appendix, and went through the daily schedule in shortened time, putting each subject through all the tests, and in the case of the Mental Multiplication and Mirror Tracing tests, making sure that all had a sufficient amount of practice to insure an accomplishment in the Monday test which could be statistically treated.

The subjects for this experiment were young girls (17–18 years of age) recently graduated from the Commercial Department of the Washington Irving High School, New York City. These subjects formed a singularly homogeneous group. They were, with only one exception, of the Hebrew race and almost all lived in the same neighborhood of lower New York. All were intelligent and ambitious; many were going to night school to continue their education along commercial lines, and most of them spent the time between tests in practicing shorthand, doing problems in accounting, or studying various psychological texts that happened to be in the laboratory,—by no means light reading. They were paid for their services and given their luncheons, which were planned by a dietician from Teachers College to furnish 1,000 calories per person per meal.

It may be said here that all record-sheets were open to the inspection of the subjects at all times, and the morning scores were usually ready and entered, before the afternoon tests were taken. The subjects knew, then, just what their standing was in all tests, and were greatly interested in improving their performance. As they understood that the purpose of the experiment was to test the effect of different air conditions upon the efficiency of their work in order that the commission might make recommendations that would help secure better working conditions for children in schools and other workers in offices and factories, they showed a good deal of scientific interest in the problem; in several cases subjects even refused offers of permanent positions in order not to jeopardize the results for their own squad.

Going on now to a description of the actual tests used, we carried on three types of tests: (1) The purely physiological observations of pulse, temperature and eye tremor, (2) The tests of efficiency in mental performances, such as addition and mental multiplication, (3) The tests of motor control and coordination. In addition the subjects' opinions in regard to the air condition and their own comfort were also recorded. Physiological observations have, as has been shown, played a very large part in previous work on ventilation, and are indeed very sensitive indices of any derangement in the heat-regulation of the body. The observation of the tremor of the eyelids squeezed together until they almost meet is in general clinical use as a diagnostic symptom of nervous disorder. We merely standardized the observation somewhat, by using an arbitrary scale for grading the amount of tremor. The addition and multiplication tests were used as examples of purely mental work, where the working of associations was the main issue, and motor exertion was reduced to a minimum. The tests of motor control were as follows:

Industrial Fatigue, to test accuracy of movement in a simple performance, when the speed is kept constant.

Tapping, to test speed in a simple performance in which accuracy is not involved.

Aiming, to test accuracy and speed in a simple performance.

Typewriting, to test accuracy and speed in a complex performance in which the subject is already highly practiced.

Mirror Tracing, to test accuracy primarily, and speed secondarily, in a fairly complex motor performance which the subject had to learn.

Hand and Arm Steadiness, to test control in the face of increasing fatigue.

Reflex Wink, to test change in an instinctive protective reaction. It will, perhaps, give a better idea of the nature of the experiment if these tests are described in the order in which they were given during the day.

The morning began with ten minutes of Addition at maximal effort. The use of continuous addition to test the effects of various outside conditions has been common since Kraepelin first developed his "Rechenhefte" to test the influence of fatigue. The use of computation tests to measure ventilation effects is reported by Flügge, Paul, Ercklentz and Thorndike. In our ten-minute Addition test the amount done in each two-minute interval was marked by the subject as the experimenter called the time. No use has so far been made of the results of this subdivision, its primary aim being to keep the subjects up to their best efforts. For this test the seven addition sheets of Thorndike were used and regularly rotated to prevent memorizing. These furnish material of such nearly equal difficulty that a long series of tests gives comparable results. The experimenter started and stopped the test with a stop-watch. The score for the test was taken as the number of sums obtained minus the incorrect ones. (A specimen blank is printed in the Appendix.)

Directly after the Addition test, before the subjects had moved from their seats, a half-minute pulse reading was taken. Two subjects then took their seats before the two motor boards which were wired together. On these boards was mounted the apparatus for the familiar Aiming, Hand Steadiness and Tapping tests. The history of the use of these tests as indices of motor capacity and control, fatigue, right-handedness, etc., in various comparative investigations in estimating age and sex factors in motor development, and the relation of physical to mental ability, has been so thoroughly discussed by Whipple[3] that a repetition here would be useless. The special form of Three Hole Aiming test used in our experiment was designed by Professor Woodworth and extensively used by him at the World's Fair in 1904. Various forms of the Steadiness test have been in use among physicians since 1888 to detect involuntary movement in paralysis agitans and other diseases. A kind of Arm Steadiness test was used in Dr. S. Weir Mitchell's clinic. The present form of the test seems to have been modified by Professor Woodworth from a test described by Scripture. The Tapping test has been used by many investigators since 1892.

The application by Hollingworth[4] of all three of these tests to his study of the effect of caffein on nervous control is of especial interest to us here. As in Hollingworth's experiment, we obtained the records by means of the Hollerith electric tabulating device in circuit with the apparatus. The use of a kymograph would, of course, have been preferable for accuracy, but with our crowded schedule and the necessity of running off all tests in very short order, the plan was not feasible. In our experiment two subjects were tested together. This factor of competition undoubtedly had a very important effect in stimulating the subjects to exert themselves in each test, and in maintaining interest throughout the long series of tests. A one-minute Aiming test was given to subjects "A" and "B" during which they put the slender point of a metal stylus as rapidly as possible into one after another of three holes arranged in a triangle. Since the electric current had been switched on by the experimenter at the word "Go," each contact of the stylus point with the metal at the bottom of the hole rang up one hit on the electric counter placed in circuit. At the end of one minute the current for both boards was switched off simultaneously, the counter-reading recorded on the mimeographed record-form for the day, and the test repeated with subjects "C" and "D." Except for the noise incidental in the manipulation of the apparatus, all tests were carried on in rigid silence.

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[3] Whipple, Guy M., "Manual of Mental and Physical Tests," 2d ed., Baltimore, Warwick and York, 1914, Part I, 130–151, 155–160.

[4] Hollingworth, H. L., "The Influence of Caffein on Mental and Motor Efficiency," *Archives of Psychology*, 1912, No. 22.

After the Aiming, a one-minute Hand Steadiness test was given. Each of the two subjects held a metal stylus-point, which was $\frac{1}{8}$ inch in diameter, within a $\frac{3}{16}$ inch hole bored in a brass plate. This plate, like the frame into which the Aiming holes were sunk, was inclined at an angle of 45°. The subjects with hand and arm bent into somewhat of a writing position, but entirely unsupported by the table, held the stylus perpendicular to the plane of the inclined plate, and tried to keep the hand so steady that the stylus did not touch the side of the hole. Every such contact caused the counter to register one error. The current was switched on after the subjects were ready with stylus inserted, and switched off before the removal of the stylus.

The next test consisted of an observation of the speed of tapping. The subjects with wrists bound to the edge of the table about an inch lower than the motor board, executed with the stylus a series of rapid taps upon a horizontal metal plate mounted on the board. After three taps the current was turned on and the subjects allowed to tap for one minute, when the current was again cut off.

Next after these motor tests came ten minutes of typewriting. Each girl, using her own Remington no. 6 typewriter, made a facsimile copy of as many pages as possible of fairly homogeneous material arranged from Thorndike's "Principles of Teaching." A credit of 10 was given for each line written, and 1 subtracted for each of about twenty-five possible errors. Since all the subjects were, because of their commercial training, quite skillful in handling the machine, their improvement at least in the early part of this test consisted principally in better adaptation to the particular machine used—a non-visible model with no back-spacer by which mistakes could be covered up.

The Arm Steadiness test, which resembled the Hand Steadiness on a larger scale, followed the typewriting period. This test was given each girl individually for two minutes. She held at shoulder height and arm's length, a slender pointer, at the end of which was inserted a brass rod. The total length of the pointer, including the $4\frac{1}{2}$ inch brass rod, was 40 inches. The subject grasped the pointer with finger-tips just coming up to a line painted on the handle, 5 inches from the end, and tried to hold the end of the brass rod, which was $\frac{3}{16}$ inches in diameter, quite steady within a hole $\frac{5}{8}$ inches in diameter. This hole had been bored out of a thin brass plate, and the plate mounted on a wooden block $\frac{3}{4}$ inch thick. A hole about 2 inches in diameter had then been cleaned out of the block, and the back of the block, opposite the $\frac{5}{8}$ inch test-hole, covered with thin metal. Electrical connections with the counter were arranged so that every contact of the brass pointer-tip with the sides of the hole or with the plate at the back of the hole caused the counter to register one error.

The Arm Steadiness test was followed by a very simple and convenient adaptation of the Mirror Tracing test. For a discussion of previous use of the Mirror Tracing test, the reader is again referred to Whipple.[5] Our apparatus consisted of a star-shaped figure composed of $\frac{3}{16}$ inch metal stripping, sunk flush into the wood base. Each of the twenty sides of the star measured 1 inch, and the ten outside points lay on the circumference of a circle 7 inches in diameter. This star presented a smooth metal design to be traced by the brass stylus. Every time the stylus left the little brass track the circuit was broken, and the counter recorded 1 error. Another error was recorded as the stylus returned to the track. Lifting the point of the stylus was similarly penalized. The subject was instructed to trace the star very accurately and to reduce the errors to a minimum. A credit of 100 was given for each entire tracing of the star during the three-minute test, which meant five for each side or 2.5 for each half side.

After the Mirror Tracing we did twenty minutes of mental multiplication of a three-place by a two-place number. The eight blanks prepared by Professor Thorndike for this purpose have been in use in the laboratory of the Commission for some time and furnish a mental test of a particularly exacting and nerve-racking kind. (A sample blank is printed in the Appendix.) The subjects were required to write the time (hours, minutes and seconds) that it took them to do each line of five examples. This furnished them with an indication of their rate of progress and served to keep interest at a high pitch.

The multiplication was followed by five minutes' work for each girl at the Industrial Fatigue test. The apparatus, which was designed by Bogardus,[6] mimics in simplified form the sort of machine that is used in "speeded-up" industrial operations, like capping tin cans, filling boxes, etc. The test was developed by Bogardus to demonstrate the fatigue resulting from long work at a monotonous motor task when the speed is kept up by some external agent—a fatigue that greatly increases the probability of mutilating accidents. The test was used in our laboratory with a much shorter observation period, merely as a somewhat simple form of motor and visual coordination test. Our apparatus consisted of a double revolving arm, pivoting at the center, and driven by a small motor. The power was transmitted to the apparatus through a system of pulleys and a speed reducer. Each arm extended about 9 inches from the center, with a 3-inch projection extending downwards. To these projections were fastened 3-inch horizontal sweeps or blades of rather stiff leather. As the arms revolved, these two little sweeps in turn brushed against a 1-inch cube, which the subject set on a 1-inch square painted on the base-board of the apparatus. The subject's procedure was as follows: with her right hand she placed one of the cubes upon the square; then the sweep attached to one arm came around and brushed the cube off the square in the direction of the left hand of the subject. She caught the first cube with her left hand, meanwhile putting the second cube on the square with her right hand. As the second arm brushed off the second cube, she transferred the block just caught in the left hand, to the right hand, placing this block, and again catching the other. This continued for five minutes at a fixed speed which, except for slight variations in the current, was equal to fifteen complete revolutions in twenty-six seconds, or about 346 blocks during the test period. The object of the test was to see how many times the cubes could be put accurately on the square. There were four possibilities of error. A second heavier set of lines $\frac{3}{8}$ of an inch outside the 1-inch square already mentioned, formed a 2-inch square. If a cube was put on so inaccurately that it touched one of the sides of the heavier outer square, 1 error was recorded. If the cube was put on obliquely, so that two of the outer lines were touched, 2 errors were recorded. If an arm hit the hand of the subject as she put on, or caught a block, 3 errors were marked against her. If she failed to put the block on at a time when the sweep was ready to carry the block off, 5 errors were called. If the subject dropped one of the cubes she could always find another on the floor at her side, so that she need not spend time hunting her original block while the 5's were counting up. The fear of losing considerable time through this stooping to get another block acted, however, as an influence in the direction of great accuracy, as did likewise the instinctive fear of getting hit by the revolving arm. The experimenter dictated the errors to an assistant as fast as they were made, counting up totals after the test.

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[5] Whipple, Guy M., "Manual of Mental and Physical Tests," 2d ed., Baltimore, 1914, Part 2, 119–132.

[6] Bogardus, Emory S., "The Relation of Fatigue to Industrial Accidents," *American Journal of Sociology*, 1911–12, 17, 206–222, 351–374, 512–539, esp. 362.

After the Industrial Fatigue test the subjects each took a turn at the apparatus designed to test the control of the protective reflex wink. Partridge,[7] Swift[8] and other experimenters with the reflex wink were mainly interested in noting the length of time it took a subject to gain absolute control of this protective reaction. As it had been found from previous studies that the reaction varies with change in the fixation point, distance of the glass from the eye, intensity of the stimulus and interval between the stimuli, an attempt was made to standardize these conditions. Everything but absolute control was counted as a wink. It often happened that a subject winked with the eye in front of the hammer, although she controlled the winking in the other eye. On that account, only the eye (the right) in front of the hammer was observed. We included this among our tests in an effort to determine whether under the ventilation conditions studied, there would take place any change in the reflex such as would lead one to suspect nervousness. The apparatus consisted of a framed piece of heavy plate glass, 12 × 10 inches, fastened upright to a narrow table. The subject sat on one side of the table, hin rher cesting on a wooden support, her eyes six inches from the glass, her right eye directly opposite the spot where a little fiber-tipped hammer would strike the glass. This hammer was 10 inches long, its head $\frac{1}{2}$ inch in diameter with a rounded point. The hammer struck the center of the glass at a point 20 inches from the table level. The subject fixated a point at the back of the room about 10 feet away. A black curtain, stretched across the glass just below the level of the eyes, concealed from the subject the movements of the experimenter on the other side of the table. After the preparatory signal the experimenter first pulled down to a horizontal position the hammer fastened at the lower edge of the frame, and then released the hammer, which was carried upward by the pull of a small spring. This arrangement provided for giving stimuli of nearly equal intensity. Twenty stimuli were given at prearranged intervals and the number of times the subject reacted to a stimulus by winking was noted. The first stimulus was given directly after the work "Ready." The experimenter recorded whether or not the subject had winked at the stimulus, meanwhile adjusting the hammer with the left hand. Then silently counting from the time the hammer was in position she gave the next stimulus as soon as the required time had elapsed. As the procedure had become practically automatic through long preliminary practice the distribution of stimuli was pretty accurately as follows:

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[7] Partridge, Geo. E., "Experiments upon the Control of the Reflex Wink," *Amer. J. of Psychology*, 1899–1900, **11**, 244–250.

[8] Swift, Edgar J., "On the Origin and Control of the Reflex Wink," *Amer. J. of Psychology*, 1903, **14**, 230–250.

Stimulus 1.	1	second	after	"Ready"	
2.	2	seconds	"	stimulus	1
3.	3	"	"	"	2
4.	4	"	"	"	3
5.	5	"	"	"	4
6.	6	"	"	"	5
7.	7	"	"	"	6
8.	8	"	"	"	7
9.	9	"	"	"	8
10.	10	"	"	"	9
11.	1	"	"	"	10
12.	2	"	"	"	11
13.	3	"	"	"	12
14.	4	"	"	"	13
15.	5	"	"	"	14
16.	6	"	"	"	15
17.	1	"	"	"	16
18.	4	"	"	"	17
19.	2	"	"	"	18
20.	5	"	"	"	19

The sharp, entirely unexpected blow on the glass in front of the subject's eye of course caused her to wink. It was the change in the subject's original reaction that we were interested in.

After the psychological tests had been completed we graded on a scale of from 1 to 5 the amount of tremor of the eyelids, calling no tremor 1 and a very decided flicker of the lids 5. We took another half-minute pulse-count, and also the temperature of the air-space between the skin and the clothing over the chest. The subjects were then asked to write their opinion of the temperature and humidity of the room, and their subjective feeling of comfort in it, according to the following scale:

Comfort.

5. I feel as comfortable as I ever do.
3. I feel about as I usually do at the close of a morning or afternoon of hard mental work.
1. I feel as uncomfortable as I would with a severe headache or an attack of the grippe.
4. My condition is half-way between 3 and 5.
2. My condition is half-way between 1 and 3.

Temperature.

50. Too hot.
40. Too warm.
30. O.K.
20. Too cool.
10. Too cold.

Moisture.

500. Too moist.
400. Moist.
300. O.K.
200. Dry.
100. Too dry.

The results obtained by the use of these scales could then be treated statistically. Luncheon was served to the subjects in the experimental room, and all of the tests were repeated in the afternoon. The schedule of the day was as follows:

9.00 Addition 10′.
9.15 Pulse 30″.
9.25 Aiming, Hand Steadiness, Tapping 1′ each.
9.40 Typewriting 10′.
10.05 Arm Steadiness 2′.
10.25 Mirror Tracing 3′. Recess.
10.55 Mental Multiplication 20′.
11.25 Industrial Fatigue 5′.
11.55 Reflex Wink in 20 stimuli.
12.10 Comfort, Temperature and Moisture Votes. Eyelid tremor.
12.15 Chest Temperature after 10′. Pulse 30″.
12.30 Lunch.
1.10 Recess.
1.20 Addition.
1.35 Aiming, Hand Steadiness, Tapping.
1.55 Typewriting.
2.10 Arm Steadiness.
2.25 Mirror Tracing. Recess.
2.55 Mental Multiplication.
3.20 Industrial Fatigue.
3.55 Reflex Wink.
4.10 Aiming, Hand Steadiness, Tapping, Arm Steadiness.
4.35 Votes. Eyelid tremor.
4.40 Temperature. Pulse.

CHAPTER III

THE EFFECT OF HUMIDITY UPON COMFORT, PULSE AND TEMPERATURE

As was explained in Chapter II the subjects in our experiment were twice a day required to write their opinion of the air condition under the headings of comfort, temperature and moisture. The results of these comfort votes are shown in Table I.

TABLE I

Average Comfort Vote at 75° F.

Greater Comfort is Indicated by Closer Approximation to 5.

Per Cent. Relative Humidity	*Squads*							
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
50	4.63	4.00	3.87	4.33	4.38	4.85	4.18	4.83
45	4.67							
37		4.45						
33			3.97	4.40				
32					4.26		4.30	
21						4.57		
20								4.67

The first column to the left of the table indicates the average relative humidity that actually prevailed; the eight columns to the right indicate by their approximation to 5 a condition of "just-as-usual" comfort. Although the differences are small, they tend to show that under moderate humidity conditions, the subjects felt more comfortable in the drier than in the wetter condition. With greater humidity contrast the subjects (except Squad G) felt more comfortable under the wetter condition.

The results of the temperature votes appear in Table II.

TABLE II

Average Temperature Vote at 75° F.

30 means "O.K." Figures Above 30 Approach "Too Warm." Figures Below 30 Approach "Too Cool"

Relative Humidity	*Squads*							
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
50	32.2	30.3	28.0	32.0	30.5	30.25	32.8	31.25
45	31.9							
37		27.8						
33			27.7	32.5				
22					28.5		30.0	
21						29.6		
20								30.25

It seems that the subjects (except Squad D) experienced the wet condition as warmer than the dry condition.

The results of the moisture votes appear in Table III.

TABLE III

Average Moisture Votes at 75° F.

300 means "O.K." Figures Above 300 Approach "Too Moist." Figures Below 300 Approach "Too Dry"

Relative	*Squads*							
Humidity	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
50	293	273	283	300	305	305	305	305
45	300							
37		295						
33			300	295				
22					298		295	
21						333		
20								298

Apparently the subjects under the earlier moderate humidity contrasts were quite confused in their notions of the prevailing humidity, but Squads D, E, G and H were correct in thinking the 50 per cent. condition more moist.

Table IV shows that the P.E. of the various averages would swamp the differences even where the greatest humidity contrast prevailed. Yet the differences reported are not entirely without significance when it is remembered that these are the opinions of quite naive subjects, totally unaware of the real temperature and humidity prevailing, who recorded their votes at the end of about three and a half hours' exposure to a condition often pronounced excessively damp or dry when they first entered the room.

TABLE IV

P.E. of Average Vote for Squads E, F, G, H

	Wet		*Dry*	
	Average	*P.E.*	*Average*	*P.E.*
Comfort	4.56	.09	4.45	.06
Temperature	31.2	.16	29.59	.24
Moisture	305	0	308	1.06

The results of the physiological observations made in the manner described in Chapter II are reported in Table V.

There is no significant difference between the results for the wet and the dry weeks. The average fall in pulse from the morning to the noon observation is 10.3 for the wet and 9.0 for the dry condition. The average fall in pulse from the morning to the afternoon observation is 5.3 for the wet and 3.4 for the dry. The average rise in temperature from noon to afternoon is 0.6 for the wet and

TABLE V

PHYSIOLOGICAL OBSERVATIONS UNDER 75° F.

	Average Temperature in Degrees F.					*Average Pulse in Beats per Minute*				
	Wet					*Dry*				
	Pulse			*Temperature*		*Pulse*			*Temperature*	
Squads	*A.M.*	*Noon*	*P.M.*	*Noon*	*P.M.*	*A.M.*	*Noon*	*P.M.*	*Noon*	*P.M.*
A	90	79	86	93.2	93.5					
A[1]	84	74	82	93.3	93.5					
B	92	81	86	92.8	93.6					
B[1]	93	79	85	93.6	94.2					
C[2]	92	81	86	96.0	96.5	83	74	83	94.1	95.4
D[2]	90	82	83	93.9	94.1	96	84	86	94.0	94.5
E	81	76	83	93.9	94.9	82	73	83	94.8	95.5
F	92	78	88	96.1	97.2	92	83	91	96.4	96.8
G	87	77	79	95.3	95.9	83	73	75	95.2	96.0
H	91	77	82	93.2	93.1	87	82	85	95.0	94.4
Average Last 6 squads	88.8	78.5	83.5	94.7°	95.3°	87.2	78.2	83.8	94.9°	95.4°

0.5 for the dry condition. It appears, then, that these physiological observations reveal no difference in the reaction of the body to the air conditions studied. Possibly more sensitive tests or more rigorous conditions would bring out a difference. It must be remembered in this connection that it was not the purpose of the commission to discover what extremes of humidity could be borne by the human organism. Since the study attempted to solve a practical problem no humidity conditions were used in the laboratory that might not have occurred under ordinary circumstances. As a matter of fact an indoor humidity of 50 per cent. or 20 per cent. would only rarely be found to exist. At least these votes and physiological observations show that for practical purposes the ventilation conditions studied are not noticeably uncomfortable or dangerous to health during the exposure period of this experiment.

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[1] Supposed "dry" weeks too moist to be included as dry.

[2] Average humidity in dry weeks 33 per cent.

CHAPTER IV

THE EFFECT OF HUMIDITY UPON AVERAGE PERFORMANCE AND UPON AVERAGE IMPROVEMENT FROM MORNING TO AFTERNOON

I. *Average Performance*

To obtain two figures, a comparison of which would directly indicate the effect of the fortnight's exposure to the wet and dry conditions upon any particular test, averages were computed from all the observations upon all the subjects for the wet weeks and from the corresponding observations for the dry weeks. Within each test the effect of the atmospheric condition can be traced in the difference between the average performance for the wet and for the dry periods. This comparison can be made for each of the squad-pairs and for the group of subjects as a whole. The latter comparison is of course a more reliable indication of the ventilation effect since inequalities of practice are better balanced out with the larger group. In making these comparisons it must be remembered that some of the tests give results in terms of simple score or amount done, some in terms of errors, and some in terms of both amount and errors. For the tests which give this double result (Addition, Mirror Tracing, Mental Multiplication, and Typewriting) the most interesting measure of the effect of the ventilation condition is probably the amount with errors subtracted (here called net score), which represents the general efficiency of the function. Table VI presents these comparisons of score, errors, and net score for all the tests.

In the "Average Performance" column, opposite the letters of the paired squads, appears the average for each one-month unit, with practice equalized by the reversal of the order of the ventilation conditions. In the "Average Performance" column opposite the words "Total Number Average" appears the average obtained from adding the net scores for all subjects in that particular test and dividing by the total number of observations involved; opposite the words "Group Average" appears the average obtained by adding the three above-mentioned paired-squad averages and dividing by three. This "Group Average" was computed in order to minimize the labor of calculating the reliability of the figure which was to stand for the ventilation effect. The P.E. of the Group

Average, which is in most cases very similar to the Total Number Average, was obtained by the use of the formulæ:

$$\sigma_{\text{dis.}} = \sqrt{\frac{\Sigma d^2}{n}}$$

$$\sigma_{\text{t.}-\text{obt. av.}} = \frac{\sigma_{\text{dis.}}}{\sqrt{n}}$$

$$\text{P.E.} = .6745\ \sigma_{\text{t.}-\text{obt. av.}}$$

where $\sigma_{\text{dis.}}$ = the mean square deviation of the distribution, the unreliability of whose average is in question,

n = the number of measures in the distribution,

$\sigma_{\text{t.}-\text{obt. av.}}$ = the mean square deviation of the probable divergence of the true from the obtained average.

In the column "Difference between Wet and Dry" appears the simple difference between the averages for the wet and dry conditions. The reliability of the difference between the Group Averages was computed by means of the formulæ:

$$\sigma_{\text{t.}-\text{obt. diff. } W-D} = \sqrt{(\sigma_{\text{t.}-\text{obt. } W})^2 + (\sigma_{\text{t.}-\text{obt. } D})^2}$$

$$\text{P.E.} = .6745\ \sigma_{\text{t.}-\text{obt. diff. } W-D}$$

where

$\sigma_{\text{t.}-\text{obt. diff. } W-D}$ = the mean square deviation of the probable divergence of the true from the obtained difference between the Wet and Dry averages,

$\sigma_{\text{t.}-\text{obt. } W}$(or $\sigma_{\text{t.}-\text{obt. } D}$) = the mean square deviation of the probable divergence of the true from the obtained average for the Wet (or Dry) condition.

A consideration of the measures of Table VI shows that although the averages are quite reliable, even the small widening of the limits of the averages that is indicated by the P.E.'s will cover up the difference in the humidity effect. The same absence of any specific effect of wetness and dryness per se is apparent from the fact that the P.E. of the difference between the wet and dry averages is in most cases larger than the obtained difference.

If, despite the size of the P.E.'s there should appear to be considerable uniformity in the effect of either condition, we might be able to conclude that the ventilation had exerted a small but consistent influence. The column headed "Favorable Condition" shows that for the experiment as a whole no such uniformity exists.

1. For each paired-squad unit the effect is fairly uniform.

C & D are favorably affected by Wet in:	*by Dry in:*
Addition	Aiming
Hand Steadiness	Tapping
Arm Steadiness	Typewriting
Mirror	
Mental Multiplication	
Fatigue	
Wink	
Tremor	

E & F are favorably affected by Wet in:	*by Dry in:*
No case	All cases

G & H are favorably affected by Wet in:	*by Dry in:*
Addition	Mirror
Aiming	Fatigue
Hand Steadiness	Wink
Tapping	
Typewriting	
Arm Steadiness	
Mental Multiplication	

2. The effect is not consistent throughout the experiment. Though the result for the squad-pairs is two out of three in favor of the Wet, we can not ignore the fact that the third case is absolutely in favor of the Dry. It will be remembered that E & F and G & H are more comparable with respect to the dryness obtained (21.5 per cent. and 21 per cent.) than are C & D and G & H (33 per cent. and 21 per cent.); so the association of C & D and G & H cannot be explained on that basis.

3. For the same test we find no case of a uniformly favorable effect of either humidity condition.

Addition is favored by Wet in the case of C & D and G & H
Aiming " " " Dry " " " " C & D " E & F
Hand Steadiness " " " Wet " " " " C & D " G & H
Tapping " " " Dry " " " " C & D " E & F
Typewriting " " " Dry " " " " C & D " E & F
Arm Steadiness " " " Wet " " " " C & D " G & H
Mirror Tracing " " " Dry " " " " E & F " G & H
Mental Multiplication " " " Wet " " " " C & D " G & H
Fatigue " " " Dry " " " " E & F " G & H
Wink " " " Dry " " " " E & F " G & H
Tremor " " " Wet " " " " C & D
Termor " " " Dry " " " " E & F
Tremor is equal for Wet and Dry in the case of G & H.

4. Taking the experiment as a whole there are 33 chances for one or the other condition to predominate. (11 tests for each of 33 squads.) Counting the number of W.'s and D.'s, we find that

in 15 cases Wet is more favorable and in 17 cases Dry is more favorable,—certainly no evidence for a differential effect of the humidity conditions studied.

5. The inconsistency in the effect upon the three squads can, of course, be explained on statistical grounds as a result of differences in initial ability and practice among the subjects. It is only when we take into account the full quota of subjects that these differences are balanced out. Comparing the averages obtained from the total number of trials we find:

Wet is more favorable for:	*Dry is more favorable for:*
Addition	Aiming
Hand Steadiness	Tapping
Typewriting	Arm Steadiness
Mental Multiplication	Mirror Tracing
Fatigue	Wink
	Tremor

Certainly as regards Average Performance, it does not appear that our subjects suffered any disadvantage under the dry condition. It would hardly be safe to make any inference from our data as to the reason why certain of the tests are better performed under one and others under the other condition. Two tests show a more reliable difference than do the rest; these are Hand Steadiness, which is better under the Wet, and Tapping, which is better under the Dry condition.

Since it is possible that the amount produced and the errors might be differently affected by the atmospheric condition, the errors and gross scores were also treated separately. Tables VII and VIII present these comparisons for the Wet and Dry periods. Though it appears that the gross score and errors are not always similarly affected, the detailed analysis of the tables may be omitted in view of the small differences and the large P.E.'s. The largest difference is in the case of Mirror Tracing errors, but even this is only about twice the P.E. In general we find no evidence that average performance is adversely affected by dryness.

II. *Improvement from Morning to Afternoon*

Although the Average Performance under a relatively longer exposure to the two humidity conditions showed no differential effect, it is conceivable that such an effect might take place during the course of the eight hour working day. Computations were accordingly made in order to find out whether there was a consistent lessening of efficiency or increased nervousness in the afternoons of dry weeks as compared with the afternoons of wet weeks.

We computed for each individual in each test the difference between her morning and her last afternoon trial on every day, calling the improvement + if the last trial was really a better performance than the first (*i. e.*, larger net score or fewer errors) and − if deterioration had taken place. These improvements were then algebraically averaged. Table IX presents this comparison. The figures were computed by means of the same formulæ and are to be interpreted in the same way as in the case of the Average Performance, except for the fact that the readings need not be made with reference to score or errors. The difference between the averages for the Wet and for the Dry are somewhat more reliable than in the case of the Average Performance, but still too small to indicate any real difference in the effect of the two conditions upon ability to improve upon the morning performance. Not all paired-squads show improvement in a particular test. Indeed in the Arm Steadiness test there is a consistent deterioration in the afternoon, both in the Wet and in the Dry weeks. In such a case the letter for the condition under which least deterioration took place appears in the "Favorable Condition" column.

1. Running through the same comparisons that were made for the Average Performance, we find that each paired-squad shows the predominating effect of one condition or the other.

C & D are favorably affected by Wet in:	*by Dry in:*
Addition	Hand Steadiness
Aiming	Typewriting
Tapping	Mirror
Arm Steadiness	Mental Multiplication
Fatigue	
Wink	
Tremor	

E & F are favorably affected by Wet in:	*by Dry in:*
Addition	Arm Steadiness
Aiming	Mirror
Hand Steadiness	Fatigue
Tapping	Wink
Typewriting	
Mental Multiplication	
Tremor	

G & H are favorably affected by Wet in:	*by Dry in:*
Tremor	All other cases

2. The squad-pairs do not agree any better than in the case of the Average Performance. C & D and E & F are favored by the Wet, G & H by the Dry. For C & D this was true of the Average Performance also; but E & F and G & H show a reversed effect.

3. For the same test we find two cases of a uniform effect upon all the paired-squads. These are Mirror Tracing, which is favored by Dry, and Eyelid Tremor, which is favored by Wet. The results for the other tests are:

Addition	is	favored	by	Wet	in	the	case	of	C & D	and	E & F
Aiming	"	"	"	Wet	"	"	"	"	C & D	"	E & F
Hand Steadiness	"	"	"	Dry	"	"	"	"	C & D	"	G & H
Tapping	"	"	"	Wet	"	"	"	"	C & D	"	E & F
Typewriting	"	"	"	Dry	"	"	"	"	C & D	"	G & H
Arm Steadiness	"	"	"	Dry	"	"	"	"	E & F	"	G & H
Mental Multiplication	"	"	"	Dry	"	"	"	"	C & D	"	G & H
Fatigue	"	"	"	Dry	"	"	"	"	E & F	"	G & H
Wink	"	"	"	Dry	"	"	"	"	E & F	"	G & H

4. Out of 33 chances, Wet predominates 15 times and Dry 18 times.

5. Considering the Total Number Averages

Wet is more favorable for:	*Dry is more favorable for:*
Addition	Hand Steadiness
Aiming	Tapping
Tremor	Typewriting
	Arm Steadiness
	Mirror
	Mental Multiplication
	Fatigue
	Wink

From this it appears that dryness, instead of exerting a harmful effect, might even be considered to facilitate improvement. Among these tests Mirror Tracing and Industrial Fatigue show the most reliable difference in improvement, both being better under the Dry condition. It will be noted that tests that show a better performance under one condition often show more improvement under the other condition. Only 13 out of 33 cases show a similar effect of either condition on both Average Performance and Average Improvement.

Tables X and XI show that the uncombined gross errors and scores are again not similarly affected by a given condition. The differences between improvement in the Wet and the Dry weeks are too small to be very significant though both Mirror Tracing and Typewriting show a gross score difference that is twice the P.E.

Using the scores and the errors in the tests as described, we can find no reliable general difference between the effect on Average Performance or on Morning to Afternoon Improvement of the 50 per cent. and 20 per cent. relative humidity. An experiment of this sort for this length of time seems to bring out none of the supposed effect of dryness on nervousness and on general efficiency.

TABLE VI

THE EFFECT OF 50 PER CENT. AND 20 PER CENT. RELATIVE HUMIDITY AT 75° F. UPON AVERAGE PERFORMANCE

(*Net Score or Errors*)

Test	*Squad*	*Wet Av. Perform.*	*P.E.*	*Dry Av. Perform.*	*P.E.*	*Favorable Condition*	*Diff. between Wet & Dry*	*P.E. of Diff.*
Addition (Net Score)	C & D	93.12		88.00		W		
	E & F	88.57		92.48		D		
	G & H	86.12		83.18		W		
	Tot. No. Av.	89.13		87.67		W	1.46	
	Group Av.	89.27	1.13	87.89	1.48	W	1.38	1.87
Aiming (Score)	C & D	130.01		130.85		D		
	E & F	133.34		137.21		D		
	G & H	129.82		128.70		W		
	Tot. No. Av.	131.00		132.08		D	1.08	
	Group Av.	131.05	.63	132.25	1.41	D	1.20	1.55
Hand Steadiness (Errors)	C & D	9.17		12.36		W		
	E & F	17.08		16.27		D		
	G & H	15.97		24.67		W		
	Tot. No. Av.	14.17		18.07		W	3.90	
	Group Av.	14.07	1.36	17.77	2.00	W	3.70	2.42
Tapping (Score)	C & D	353.19		361.70		D		
	E & F	357.88		365.49		D		
	G & H	359.75		354.86		W		
	Tot. No. Av.	367.07		360.42		D	3.35	
	Group Av.	356.94	1.08	360.68	1.71	D	3.74	2.02

TABLE VI—*Continued*

Test	*Squad*	*Wet* *Av. Perform.*	*P.E.*	*Dry* *Av. Perform.*	*P.E.*	*Favorable Condition*	*Diff. between Wet & Dry*	*P.E. of Diff.*
Typewriting (Net Score)	C & D	359.40		361.58		D		
	E & F	325.19		330.65		D		
	G & H	318.92		311.38		W		
	Tot. No. Av.	333.80		333.60		W	.20	
	Group Av.	334.50	6.93	334.54	8.06	D	.04	10.62
Arm Steadiness (Errors)	C & D	15.74		18.83		W		
	E & F	19.45		10.99		D		
	G & H	11.33		14.76		W		
	Tot. No. Av.	15.32		14.87		D	.45	
	Group Av.	15.50	1.29	14.86	1.25	D	.64	1.79
Mirror Tracing (Net Score)	C & D	404.56		331.88		W		
	E & H	288.22		359.04		D		
	G & H	344.66		356.68		D		
	Tot. No. Av.	344.95		349.83		D	4.88	
	Group Av.	345.81	18.56	349.20	4.79	D	3.39	19.14
Mental Multiplication (Net Score)	C & D	194.00		125.31		W		
	E & F	305.11		309.97		D		
	G & H	273.80		259.05		W		
	Tot. No. Av.	257.64		231.07		W	26.57	
	Group Av.	257.63	18.24	231.44	30.37	W	26.19	35.43

TABLE VI—*Concluded*

Test	*Squad*	*Wet* *Av. Perform.*	*P.E.*	*Dry* *Av. Perform.*	*P.E.*	*Favorable Condition*	*Diff. between Wet & Dry*	*P.E. of Diff.*
Industrial Fatigue (Errors)	C & D	12.80		16.76		W		
	E & F	15.58		14.91		D		
	G & H	17.98		16.72		D		
	Tot. No. Av.	15.58		16.16		W	.58	
	Group Av.	15.45	.83	16.13	.34	W	.68	.89
Reflex Wink (Errors)	C & D	13.25		13.57		W		
	E & F	15.20		12.77		D		
	G & H	9.88		8.86		D		
	Tot. No. Av.	12.65		11.60		D	1.05	
	Group Av.	12.77	.86	11.73	.80	D	1.04	1.17
Eyelid Tremor (Errors)	C & D	1.47		1.99		W		
	E & F	2.90		2.39		D		
	G & H	2.04		2.04		=		
	Tot. No. Av.	2.14		2.13		D	.01	
	Group Av.	2.13		2.14		W	.01	

TABLE VII

THE EFFECT OF 50 PER CENT. AND 20 PER CENT. RELATIVE HUMIDITY AT 75° F. UPON AVERAGE PERFORMANCE

(Errors)

		Wet		*Dry*				
Test	*Squad*	*Av. Error*	*P.E.*	*Av. Error*	*P.E.*	*Favorable Condition*	*Diff. between Wet & Dry*	*P.E. of Diff.*
Addition (Errors)	C & D	8.31		8.77		W		
	E & F	5.30		4.94		D		
	G & H	5.40		6.78		W		
	Total No. Av.	6.29		6.84		W	.55	
	Group Av.	6.34	.55	6.83	.61	W	.49	.82
Mirror	C & D	78.84		71.37		D		
Tracing (Errors)	E & F	98.90		71.97		D		
	G & H	70.79		74.50		D		
	Total No. Av.	82.34		72.71		D	9.63	
	Group Av.	82.84	4.61	72.61	.53	D	10.23	4.64
Mental Multiplication (Errors)	C & D	47.29		48.11		W		
	E & F	40.17		43.97		W		
	G & H	36.77		33.80		D		
	Total No. Av.	41.41		41.95		W	.54	
	Group Av.	41.41	1.71	41.96	2.35	W	.55	2.90
Typewriting (Errors)	C & D	67.84		61.90		D		
	E & F	37.30		39.20		W		
	G & H	24.11		31.55		W		
	Total No. Av.	42.22		43.72		W	1.50	
	Group Av.	43.08	7.16	44.22	4.18	W	1.14	8.30

TABLE VIII

THE EFFECT OF 50 PER CENT. AND 20 PER CENT. RELATIVE HUMIDITY AT 75° F. UPON AVERAGE PERFORMANCE

(Gross Score)

Test	*Squad*	*Wet Av. Perform.*	*P.E.*	*Dry Av. Perform.*	*P.E.*	*Favorable Condition*	*Diff. between Wet & Dry*	*P.E. of Diff.*
Addition (Gross Score)	C & D	101.44		97.06		W		
	E & F	93.87		97.42		D		
	G & H	91.52		90.15		W		
	Total No. Av.	95.43		94.67		W	.76	
	Group Av.	95.61	1.65	94.88	1.32	W	.73	2.11
Mirror Tracing (Gross Score)	C & D	481.91		396.80		W		
	E & F	387.10		431.10		D		
	G & H	415.37		431.56		D		
	Total No. Av.	426.79		420.34		W	6.45	
	Group Av.	428.13	15.53	419.82	6.35	W	8.31	16.74
Mental Multiplication (Gross Score)	C & D	241.29		172.00		W		
	E & F	345.29		354.05		D		
	G & H	312.00		292.86		W		
	Total No. Av.	299.52		272.58		W	26.94	
	Group Av.	299.53	17.08	272.97	29.50	W	26.56	34.09
Typewriting (Gross Score)	C & D	427.23		423.53		W		
	E & F	362.51		369.77		D		
	G & H	343.25		342.89		W		
	Total No. Av.	376.01		377.29		D	1.07	
	Group Av.	377.66	14.04	378.73	13.10	D	1.07	19.17

TABLE IX

THE EFFECT OF 50 PER CENT. AND 20 PER CENT. RELATIVE HUMIDITY AT 75° F. UPON AVERAGE IMPROVEMENT FROM MORNING TO AFTERNOON

(Net Score or Errors)

Test	*Squad*	*Wet* *Av. Improvmt.*	*P.E.*	*Dry* *Av. Improvmt.*	*P.E.*	*Favorable Condition*	*Diff. between Wet & Dry*	*P.E. of Diff.*
Addition (Net Score)	C & D	+3.91		+2.11		W		
	E & F	+2.17		+1.73		W		
	G & H	+2.30		+2.89		D		
	Total No. No.	+2.77		+2.28		W	0.49	
	Group Av.	+2.79	.31	+2.24	.19	W	0.55	.36
Aiming (Score)	C & D	+0.04		+0.01		W		
	E & F	+3.27		−3.44		W		
	G & H	+4.47		+5.08		D		
	Total No. Av.	+2.68		+0.75		W	1.93	
	Group Av.	+2.59	.73	+0.55	1.36	W	2.04	1.54
Hand Steadiness (Errors)	C & D	+2.36		+4.24		D		
	E & F	−0.80		−2.40		W		
	G & H	−0.26		+2.83		D		
	Total No. Av.	+0.40		+1.64		D	1.24	
	Group Av.	+0.43	.54	+1.55	1.11	D	1.12	1.23
Tapping (Score)	C & D	+4.41		+2.08		W		
	E & F	+4.18		+2.78		W		
	G & H	−0.96		+9.95		D		
	Total No. Av.	+2.39		+5.14		D	2.75	
	Group Av.	+2.54	.96	+4.93	1.39	D	2.39	1.69

TABLE IX—*Continued*

Test	*Squad*	*Wet* *Av. Improvmt.*	*P.E.*	*Dry* *Av. Improvmt.*	*P.E.*	*Favorable Condition*	*Diff. between Wet & Dry*	*P.E. of Diff.*
Typewriting (Net Score)	C & D	+9.48		+21.34		D		
	E & F	+5.80		+ 3.76		W		
	G & H	−4.25		+ 2.56		D		
	Total No. Av.	+3.32		+ 9.03		D	5.71	
	Group Av.	+3.68	2.26	+ 9.22	3.34	D	5.54	4.04
Arm Steadiness (Errors)	C & D	−1.78		−2.20		W		
	E & F	−2.51		−2.12		D		
	G & H	−2.40		−1.80		D		
	Total No. Av.	−2.24		−2.03		D	0.21	
	Group Av.	−2.23	.13	−2.04	.07	D	0.19	.15
Mirror Tracing (Net Score)	C & D	+19.17		+20.66		D		
	E & F	+17.76		+30.29		D		
	G & H	+20.42		+29.88		D		
	Total No. Av.	+19.42		+27.30		D	8.12	
	Group Av.	+19.12	.42	+26.94	1.73	D	7.82	1.79
Mental Multiplication (Net Score)	C & D	+ 7.54		+ 8.00		D		
	E & H	+23.83		+17.17		W		
	G & H	+ 2.70		+18.68		D		
	Total No. Av.	+11.35		+14.60		D	3.25	
	Group Av.	+11.36	3.53	+14.61	1.84	D	3.25	3.98

TABLE IX—*Concluded*

Test	*Squad*	*Wet* *Av. Improvmt.*	*P.E.*	*Dry* *Av. Improvmt.*	*P.E.*	*Favorable Condition*	*Diff. between Wet & Dry*	*P.E. of Diff.*
Industrial Fatigue (Errors)	C & D	+1.69		+0.25		W		
	E & F	+1.23		+4.14		D		
	G & H	+0.37		+8.30		D		
	Total No. Av.	+1.06		+4.42		D	3.36	
	Group Av.	+1.10	.22	+4.23	1.28	D	3.13	1.30
Reflex Wink (Errors)	C & D	+0.91		+0.23		W		
	E & F	+1.49		+1.91		D		
	G & H	+0.67		+2.17		D		
	Total No. Av.	+1.01		+1.47		D	0.46	
	Group Av.	+1.02	.14	+1.43	.34	D	0.41	.36
Eyelid Tremor (Errors)	C & D	+0.37		+0.08		W		
	E & F	+0.02		0.00		W		
	G & H	+0.32		+0.07		W		
	Total No. Av.	+0.24		+0.06		W	0.18	
	Group Av.	+0.23		+0.05		W	0.18	

+ Indicates better performance (larger net score or fewer errors).
− Indicates worse performance.

TABLE X

The Effect of 50 Per Cent. and 20 Per Cent. Relative Humidity at 75° F. upon Average Improvement from Morning to Afternoon

(*Errors*)

Test	*Squad*	*Wet* *Av. Improvmt.*	*P.E.*	*Dry* *Av. Improvmt.*	*P.E.*	*Favorable Condition*	*Diff. between Wet & Dry*	*P.E. of Diff.*
Addition (Errors)	C & D	+1.09		+0.17		W		
	E & F	+0.32		+0.29		W		
	G & H	+0.35		+0.73		D		
	Total No. Av	+0.57		+0.42		W	.15	
	Group Av.	+0.58	.14	+0.53	.10	W	.05	.16
Mirror Tracing (Errors)	C & D	−5.28		−5.42		W		
	E & F	−5.92		−8.18		W		
	G & H	−4.48		−2.50		D		
	Total No. Av.	−5.19		−5.21		W	.02	
	Group Av.	−5.22	.23	−5.33	.88	W	.11	.91
Mental Multiplication (Errors)	C & D	−1.31		−4.57		W		
	E & F	−1.60		+0.18		D		
	G & H	−0.51		+3.26		D		
	Total No. Av.	−1.14		−0.38		D	.76	
	Group Av.	−1.14	.18	−0.37	1.26	D	.77	1.27
Typewriting (Errors)	C & D	+6.37		+1.23		W		
	E & F	+1.86		+4.88		D		
	G & H	+0.18		−0.31		W		
	Total No. Av.	+2.68		+1.82		W	.86	
	Group Ave.	+2.80	1.02	+1.93	.85	W	.87	1.33

TABLE XI

THE EFFECT OF 50 PER CENT. AND 20 PER CENT. RELATIVE HUMIDITY AT 75° F. UPON AVERAGE IMPROVEMENT FROM MORNING TO AFTERNOON

(*Gross Score*)

Test	*Squad*	*Wet* *Av. Improvmt.*	*P.E.*	*Dry* *Av. Improvmt.*	*P.E.*	*Favorable Condition*	*Diff. between Wet & Dry*	*P.E. of Diff.*
Addition (Gross Score)	C & D	+2.83		+ 1.91		W		
	E & F	+1.86		+ 1.44		W		
	G & H	+1.95		+ 1.77		W		
	Total No. Av.	+2.20		+ 1.72		W	.48	
	Group Av.	+2.21	.17	+ 1.71	.07	W	.50	.18
Mirror Tracing (Gross Score)	C & D	+21.31		+33.05		D		
	E & F	+23.64		+20.93		W		
	G & H	+25.30		+31.89		D		
	Total No. Av.	+23.57		+28.76		D	5.19	
	Group Av.	+23.41	.63	+28.62	2.13	D	5.21	2.21
Mental Multiplication (Gross Score)	C & D	+ 8.86		+ 9.71		D		
	E & F	+25.43		+16.76		W		
	G & H	+ 4.00		+15.43		D		
	Total No. Av.	+12.76		+13.94		D	1.18	
	Group Av.	+12.76	3.58	+13.96	1.19	D	1.20	3.77
Typewriting (Gross Score)	C & D	+3.14		+20.20		D		
	E & F	+3.89		− 0.94		W		
	G & H	−4.45		+ 2.77		D		
	Total No. Av.	+0.62		+ 7.25		D	6.63	
	Group Av.	+0.86	1.47	+ 7.34	3.59	D	6.48	3.88

CHAPTER V

Correlations Among the Tests

The original purpose in working out the correlations was to see whether there existed a body of tests with high inter-correlations that could be used as a composite measure of nervous and motor control. The use of the data without reference to the ventilation conditions under which it was collected is permissible since it was not possible to trace any ventilation effect in the records. Accordingly for every test the data for any one individual were arranged in two equal groups to permit of correction for attenuation due to chance errors, which do not balance out in the case of correlations as in the case of averages, but cause the coefficient to approximate zero. This division into two groups was accomplished by adding alternate tests, putting the trials numbered 1 into Group I, the trials numbered 2 into Group II. The following table shows the chronological position of tests added to form Group I and Group II for every individual in every test, the procedure varying somewhat according to whether there were two or three tests a day.

	A.M.	*P.M.*	*A.M.*	$P.M._{I}$	$P.M._{II}$
Monday	1	2	1	2	1
Tuesday	2	1	2	1	2
Wednesday	1	2	1	2	1
Thursday	2	1	2	1	2
Friday	1	2	1	2	1
Monday	2	1	2	1	2
Tuesday	1	2	1	2	1
Wednesday	2	1	2	1	2
Thursday	1	2	1	2	1
Friday	2	1	2	1	2

On the few occasions when a test in one group was missing, the corresponding test was dropped from the second group. An average was computed for each individual in both groups of every test and these averages treated as the original measures to which was applied the Pearson correlation formula:

$$\frac{\Sigma X \cdot Y}{\sqrt{\Sigma X^2} \cdot \sqrt{\Sigma Y^2}}$$

and the Spearman correction formula used by Thorndike in the shortened form:

$$r_{pq} = \frac{\sqrt{(r_{p1q2})(r_{p2q1})}}{\sqrt{(r_{p1p2})(r_{q1q2})}}$$

That is, to obtain the corrected r between Addition and Multiplication the four raw coefficients of correlation used in the correction formula were:

1) the r of Group I of Addition with Group II of Multiplication
2) the r of Group II of Addition with Group I of Multiplication
3) the r of Group I of Addition with Group II of Addition
4) the r of Group I of Multiplication with Group II of Multiplication

The P.E.'s of the raw coefficients were computed by means of the formula:

$$\text{P.E.}_{\cdot r} = .6745\frac{1 - r^2}{\sqrt{n}}$$

The number of cases for all the correlations was 21.

It should be explained that the signs of the deviation in the case of tests that gave a result in terms of errors, were changed so that a positive correlation always means the correlation between good performances.

Table XII shows the raw correlations for the two groups arranged as explained above, together with their reliability. Table XIII shows the corrected coefficients, and also the average of the two raw group-coefficients. It will be noted that the correction does not raise the coefficient very much. Indeed the usefulness of correcting for attenuation when a long series of measurements has been made would be doubtful did not the method furnish a check upon the reliability of the work. The blanks in the corrected coefficient triangle represent practically a zero correlation; in those cases the correction formula could not be applied because the raw coefficients were themselves of unlike sign. All the coefficients were worked out to three places, the two-place figure in the tables being always an approximation. Table XIV shows the correlations of the Fatigue test whose inter-group or reliability coefficient was only .24. Table XV shows the average correlation of each test with all the others.

Eight things are noteworthy about the correlations. Unless otherwise stated, the reference is to corrected correlations.

1. The high raw correlations between the two groups arranged from data of the same test. They range from .90 to .99. The only exception is the Industrial Fatigue test whose correlations are given in a separate table. Since chance is so largely operative in

determining an individual's performance in this test as given in our experiment, it cannot be regarded as a useful measure, nor can much confidence be placed in the amounts of its correlation with other tests.

2. The low correlations among tests that might in a common sense way be taken as measures of the same sort of motor ability. The more reliable correlations of this sort are:

Aiming with Tapping	.31
Aiming with Wink	.27
Hand Steadiness with Typewriting	.23
Hand Steadiness with Tremor	.21
Tapping with Typewriting	.18
Tapping with Mirror	.15
Tapping with Tremor	.22
Typewriting with Arm Steadiness	.30
Typewriting with Mirror	.38

3. The indifferent correlations among tests that one would expect to be functionally connected:

Aiming with Mirror	−.10
Aiming with Tremor	−.04 and .02 (raw)
Hand Steadiness with Tapping	.07
Hand Steadiness with Mirror	.13
Hand Steadiness with Wink	−.10
Tapping with Arm Steadiness	−.01 and .07 (raw)
Tapping with Wink	−.09
Typewriting with Tremor	−.08
Arm Steadiness with Tremor	−.05
Arm Steadiness with Mirror	.02 and −.01 (raw)
Mirror with Wink	−.13
Mirror with Tremor	.12
Wink with Tremor	.13

4. The rather curious negative correlations between tests of supposedly related motor abilities:

Aiming with Typewriting	−.35
Aiming with Arm Steadiness	−.45
Aiming with Hand Steadiness	−.42
Typewriting with Wink	−.31
Arm Steadiness with Wink	−.48

5. The low correlation between the two intellectual tests,

Addition and Mental Multiplication	.22

6. The fact that Addition gives a reliably positive correlation with only two tests aside from Mental Multiplication,

Addition with Hand Steadiness	.24
Addition with Typewriting	.15

7. The fact that no motor test gives a reliable positive correlation with Mental Multiplication, and the fact that Mental Multiplication is negative with Hand Steadiness − .15, and more strongly negative with Tapping − .24, with Arm Steadiness − .32, and with Tremor − .49.

8. The low negative correlation between Hand and Arm Steadiness − .16 which is a surprising thing in view of the fact that these two tests almost always correlate in like manner with other tests, and would presumably test the same sort of function.

To bring together this loosely connected group of correlations into any sort of consistent scheme is almost impossible. These conclusions can be drawn:

1. The distinction between the purely intellectual Mental Multiplication and the motor tests, particularly the inverse relation with those designed especially to test nervous control—Hand Steadiness, Arm Steadiness, Tremor—seems evident. We should not, however, lay much weight upon this apparent motor incapacity of the more intellectually gifted until this point has been specifically investigated with different groups of subjects.

2. Addition is not an intellectual performance of the same order as Mental Multiplication as is shown by its incomplete resemblance to Mental Multiplication .22, and by its tendency to correlate positively with many of the motor tests to which Multiplication is opposed.

3. Typewriting seems to hold a sort of intermediate position between a purely intellectual and a purely motor test; it shows an indifferent correlation with Multiplication, a low positive correlation with Addition and higher positive correlation with four motor tests.

4. Mirror Tracing seems to be somewhat the same sort of Test as Typewriting as is shown by the fact that it correlates .38 and shows, in common with Typewriting, positive (though lower) correlations with Addition, Hand Steadiness, Tapping and Mental Multiplication.

The relations among the more highly correlated tests appear in diagrams A and B, in which + bonds indicate reliable positive correlations between tests. Only tests directly connected by + bonds correlate positively; reliable negative correlations are indicated by − bonds.

DIAGRAM A

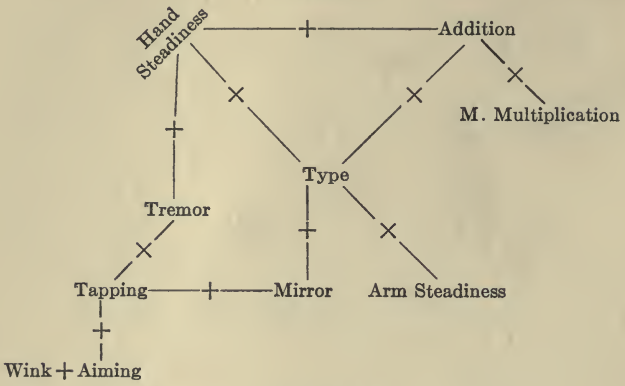
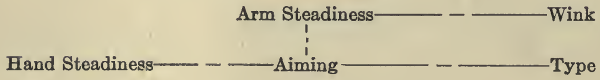


DIAGRAM B



How to account for the antagonism between Aiming and the other tests is an unsolved problem. The connection between Typewriting, Mirror Tracing and the other motor tests is intelligible, since they obviously have common motor elements. According to the table of average correlations, Mirror Tracing shows the closest connection with the rest of our group of tests; next come Typewriting and Tapping, then Addition and lastly Hand Steadiness. Wink, Arm Steadiness and Aiming are negative in that order, Tremor being practically zero. The only conclusion that can be drawn from these correlations is that ability in these tests of nervous and motor control seems to be a good deal more specialized than we have previously believed to be the case.

If we attempt to compare these correlations with those found by other investigators we find that although there is an enormous literature[1] on the subject, motor tests such as those examined in this study have only rarely been used in other researches.

Burt[2] found corrected correlations for Mirror Tracing with Tapping of .48 in an elementary school and 1.00 in a preparatory school. Although our method for both tests differed somewhat from that of Burt, we found a much lower coefficient, .15.

[1] Simpson, "Correlations of Mental Abilities," *Teachers College, Columbia University, Contributions to Education*, 1912, No. 53. Giese, "Korrelationen psychischer Functionen," *Ztschr. f. angew. Psych.*, 1915, **10**, 193.

[2] Burt, "Experimental Tests of General Intelligence," *Brit. J. Psych.*, 1909, **3**, 94.

Hollingworth[3] reported an interesting series of correlations for subjects who almost reached the limit of improvement. Correlations computed for the 1st, 5th, 25th, 80th, and 205th trials showed, contrary to the findings of Binet and Burt and in agreement with those of Spearman, that coefficients become positive and tend to become greater the longer the practice is continued. Hollingworth inclines to the theory that variability is reduced, and ability more and more accurately measured as the individual nears his ultimate capacity. Our data has not yet been worked up in regard to this problem; the correlations reported in this chapter were computed from measures at about the middle of the fortnight's practice curve. Not all of Hollingworth's series showed the type of change demanded by his theory. For example, Addition with the Three Hole Aiming test correlated: —.21, .32, .22, .19, .16. Our two group correlations are: — .11 and .01. Hollingworth's correlations for Addition and Tapping were: .45, .55, .49, .55, .57. Ours are: —. 16 and — .05. Hollingworth's correlations for Tapping and Aiming were — .25, .50, .13, .26, .39. Ours are: .32 and .26. Thus it appears that our negative results for Addition and Tapping are completely at variance with the high positive ones of Hollingworth. In the other two cases our coefficients approximate some one of Hollingworth's. A matter which can produce such startling effects on the size of coefficients certainly merits very special investigation.

A comparison between our results and those of Chapman[4] can be made on the point of the correlation between Addition and Mental Multiplication. He found as group coefficients — .02 and .02, a practically indifferent correlation, whereas ours are .23 and .20. Chapman's correlations were between initial abilities and ours between average abilities, which might possibly account for the difference.

The correlation between Tapping and Addition reported by Giese[5] agrees closely with Hollingworth's findings, .42 for men and .38 for women. Possibly all these differences will eventually be explained on the basis of selection. With our present knowledge of the subject of correlation we can do little more than echo Brown's[6] philosophical conclusions: "The correlation between different

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[3] Hollingworth, "Correlation of Abilities as Affected by Practice," *J. Ed. Psych.*, 1913, 4, 405.

[4] Chapman, "Individual Differences in Ability and Improvement and Their Correlations," New York, *Teachers College, Columbia University, Contributions to Education*, 1914, No. 63.

[5] Giese, "Korrelationen psychischer Functionen," *Ztschr. f. angew. Psych.*, 1915, 10, 193.

[6] Brown, "The Essentials of Mental Measurement," London, Cambridge Univ. Press, 1911.

TABLE XII

RAW CORRELATIONS OF THE TWO GROUPS (UPPER RIGHT HAND TRIANGLE)
P.E. OF THE RAW COEFFICIENTS (LOWER LEFT HAND TRIANGLE)

	Addition		*Aiming*		*Hand Steadiness*		*Tapping*		*Type-writing*		*Arm Steadiness*		*Mirror*		*Multi-plication*		*Wink*		*Tremor*	
	I	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*
Addition II			−.11		.23		−.16		.19		.05		.16		.20		−.14		−.09	
" I				.01		.24		−.05		.12		.08		.11		.23		−.15		−.06
Aiming II	.15				−.41		.32		−.34		−.38		−.07		−.09		.22		−.04	
" I		.15				−.39		.26		−.34		−.49		−.14		0		.32		.02
Hand Steadiness II	.14		.12				.03		.22		−.15		.13		−.14		−.09		.20	
" " I		.14		.12				.18		.24		−.16		.12		−.16		−.11		.19
Tapping II	.15		.14		.14				.24		−.01		.20		−.28		−.09		.26	
" I		.14		.13		.15				.12		.07		.11		−.20		−.08		.16
Typewriting II	.15		.13		.14		.14				.29		.32		.04		−.33		−.13	
" I		.14		.13		.14		.14				.30		.42		−.02		−.29		−.04
Arm Steadiness II	.15		.11		.14		.15		.13				−.01		−.31		−.47		−.04	
" " I		.15		.13		.14		.15		.13				.02		−.32		−.48		−.06
Mirror II	.15		.14		.14		.15		.12		.15				.15		−.15		.09	
" I		.14		.15		.14		.14		.13		.15				.12		−.11		.14
Multiplication II	.14		.15		.14		.14		.15		.13		.15				.01		−.47	
" I		.14		.15		.14		.14		.15		.13		.14				.02		−.46
Wink II	.14		.13		.15		.15		.13		.11		.15		.15				.09	
" I		.14		.14		.15		.15		.13		.11		.14		.15				.16
Tremor II	.15		.15		.14		.14		.15		.15		.14		.12		.14			
" I		.15		.15		.14		.14		.14		.15		.15		.11		.15		

psychical abilities is not very close. . . . The size of the correlation coefficient varies greatly from one group of subjects to another. This shows how great is the danger of spurious correlation due to heterogeneity of material. . . . Correlations may be very low even within a set of mental tests which appear to measure closely related mental abilities, and this when the reliability coefficients are high."

TABLE XII(*a*)

INTER-GROUP CORRELATIONS AND THEIR RELIABILITY

	r Group I and Group II	P.E.
Addition	.96	.01
Aiming	.93	.02
Hand Steadiness	.98	.004
Tapping	.96	.01
Typewriting	.99	.002
Arm Steadiness	.99	.002
Mirror Tracing	.96	.01
Multiplication	.99	.002
Reflex Wink	.99	.003
Eyelid Tremor	.90	.03

TABLE XIII

RAW CORRELATIONS (AVERAGE OF THE TWO GROUP CORRELATIONS OF TABLE XII) IN UPPER RIGHT HAND TRIANGLE.
CORRECTED CORRELATIONS IN LOWER LEFT HAND TRIANGLE

	Addition	*Aiming*	*Hand Steadiness*	*Tapping*	*Type-writing*	*Arm Steadiness*	*Mirror*	*Multi-plication*	*Wink*	*Tremor*
Addition		−.10	.23	−.11	.15	.07	.14	.21	−.15	−.07
Aiming			−.40	.29	−.34	−.44	−.10	.04	.27	−.01
Hand Steadiness	.24	−.42		.10	.23	−.16	.13	−.15	−.10	.20
Tapping	−.09	.31	.07		.18	.03	.15	−.24	−.09	.21
Typewriting	.15	−.35	.23	.18		.29	.37	.01	−.31	−.08
Arm Steadiness	.06	−.45	−.16		.30		.01	−.32	−.47	−.05
Mirror	.14	−.10	.13	.15	.38			.13	−.13	.12
Multiplication	.22		−.15	−.24		−.32	.14		.01	−.46
Wink	−.15	.27	−.10	−.09	−.31	−.48	−.13	0		.12
Tremor	−.08		.21	.22	−.08	−.05	.12	−.49	.13	

Note: As the correlations were originally worked out to the third place this average will not exactly equal the average of the two-place coefficients of Table XII.

TABLE XIV

Raw Correlations of Fatigue with Other Tests. P.E. about .15

	Fatigue I	Fatigue II
Addition II	.37	
" I		.26
Aiming II	−.38	
" I		−.21
Hand Steadiness II	0	
" " I		.34
Tapping II	.05	
" I		.32
Typewriting II	.24	
" I		.12
Arm Steadiness II	.09	
" " I		.02
Mirror II	.14	
" I		.48
Multiplication II	−.02	
" I		.33
Wink II	−.05	
" I		−.30
Tremor II	−.11	
" I		−.06
Fatigue II	.24	
" I		.24

TABLE XV

Average Correlation of each Test with all the Others

Computed from corrected correlations

Addition	.05
Aiming	−.08
Hand Steadiness	.01
Tapping	.06
Typewriting	.06
Arm Steadiness	−.12
Mirror Tracing	.09
Mental Multiplication	−.10
Wink	−.16
Tremor	0

CHAPTER VI

PRACTICE EFFECT DURING A FORTNIGHT AND VARIATIONS IN EFFICIENCY DURING THE WORKING DAY

I. *Practice Effect During a Fortnight*

THE general situation in our experiment was particularly favorable for a comparison of the shape of the practice curves in eight of our tests. Although a fortnight is unfortunately rather a short practice period, still the regularity of the daily procedure and the homogeneity of the groups of subjects make the results quite reliable.

The tests studied with reference to the practice curve present an interesting group for comparison since they comprise:

(*a*) a motor test in which a new and difficult hand and eye coordination is learned (Mirror Tracing), a motor test of a function in which the subjects were already considerably practiced (Typewriting), a mental test in which a new and difficult process is learned (Mental Multiplication), a mental test of a process in which the subjects have had a good deal of practice (Addition), and

(*b*) four tests of relatively simple sensori-motor functions in which the possibility of improvement is much more limited by physiological factors (Hand Steadiness, Arm Steadiness, Tapping, Aiming).

The first group (*a*) was given twice a day to each subject, the second group (*b*) three times a day. In studying each test, the data for all our subjects were amalgamated to give a fortnight's practice curve. Table XVI and Graph I represent these curves for the tests that were given morning and afternoon; Table XVII and Graph II represent the curves for the tests given morning, early afternoon and late afternoon. The abscissæ represent successive practice periods throughout the two weeks, the ordinates represent actual products (net score) except in the case of the two Steadiness tests, where errors are plotted, the direction of the curves being simply reversed to permit of comparison with the curves of product. Each point on the curve is the average of the records of all subjects for the test at that particular practice period.

No intensive discussion of these curves will be attempted. The whole subject of the shape of the practice curve and its dependence upon the order, difficulty and time of formation of bonds has been examined at length by Thorndike in his analysis of "Changes in the Rate of Improvement."[1] It will be of interest, however, to note certain characteristic differences in the shape of the curves. From a consideration of these tables and graphs it appears that:

1. The four simple sensori-motor tests show very similar curves.

2. Aiming and Steadiness during the first three days show an initial acceleration in all cases followed by a very gradual rise.

3. Tapping, among the motor tests, comes nearest to showing a rectilinear relation between product and time spent in practice.

4. The two Steadiness tests show a practice level by Wednesday of the second week.

5. Tapping and Aiming resemble each other more than they resemble the Steadiness tests.

6. The simple motor tests are much more variable than the intellectual tests. The convexity of the curve and the variability of the performance in Typewriting show the degree of its partial relationship with both the intellectual and the motor tests.

For all these the initial rise probably represents the adjustment to the new apparatus and to the general laboratory situation. The fact of variability is probably to be interpreted in the light of the possibility of further improvement which is naturally small in such narrow performances as Aiming, Tapping, and Steadiness, and could not have been great in Typewriting since these subjects had had a considerable amount of practice.

7. Addition shows a surprising amount of improvement considering the fact that these subjects (high school graduates) had already had a long experience with numbers, and that they had had specific training in bookkeeping.

8. Since there is no possibility of reaching the limit of improvement in a complex function like Mental Multiplication in the 400 minutes of actual practice time, this curve shows a somewhat more rectilinear relation between product and time. There is a slight acceleration at the beginning and then a rapid rise to the end of the experiment.

9. Mirror Tracing seems to be a function very similar to Mental Multiplication. There is the same rapid rise with no evidence that the function is nearing a practice level.

10. During this short period of practice none of these curves shows a plateau; some of the functions tested were of course too simple to furnish an opportunity for the formation of higher habits; others did not have sufficient exercise to permit of this. Lack of

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[1] Thorndike, "Educational Psychology," II, 235.

interest would, moreover, hardly have been operative in an experiment where the social situation was stimulating the subjects toward continuous improvement.

TABLE XVI

Composite Practice Curves

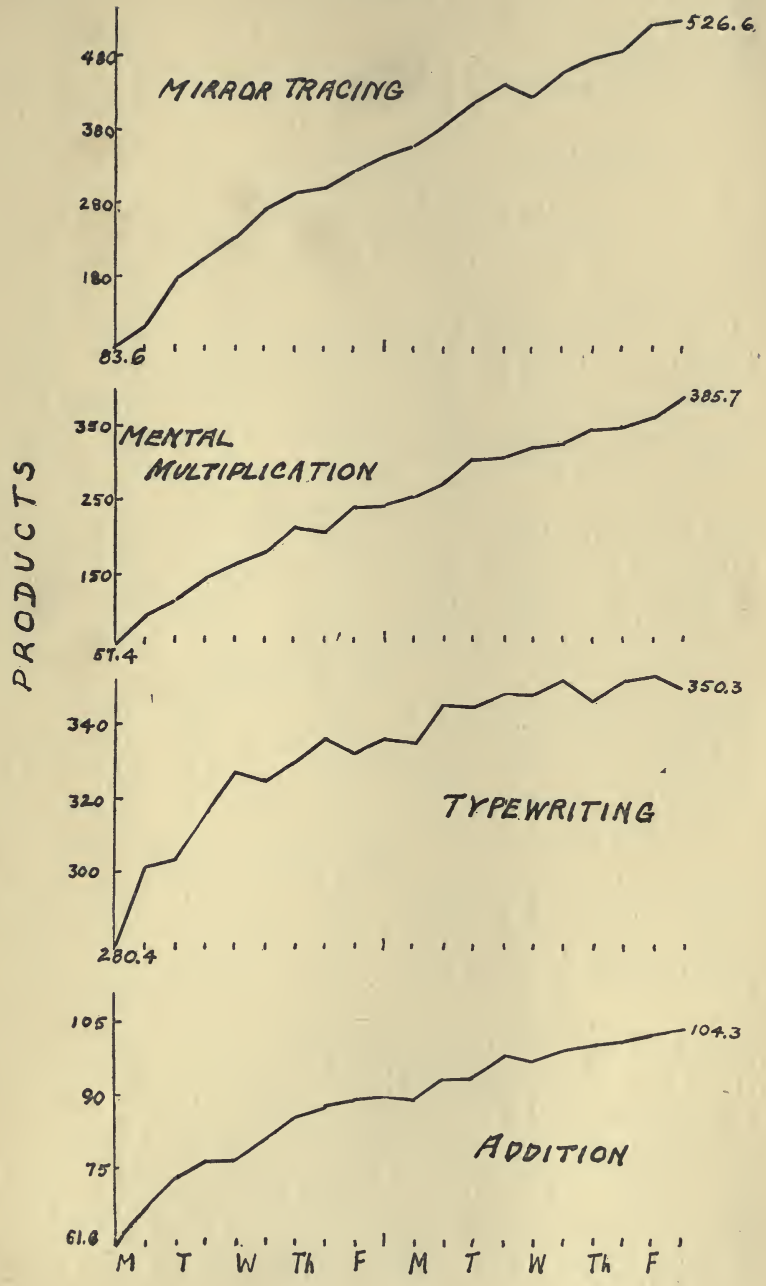
Each Figure is the Average of 22 Determinations[16]

	Week I		Week II	
	A.M.	*P.M.*	*A.M.*	*P.M.*
		Mirror Tracing (Net Score)		
Monday	83.6	124.7	358.3	387.6
Tuesday	180.6	215.9	414.8	437.6
Wednesday	237.1	269.7	421.0	458.5
Thursday	292.9	300.5	478.7	488.2
Friday	323.9	342.4	523.4	527.6
		Mental Multiplication (Net Score)		
Monday	57.4	93.3	254.4	271.8
Tuesday	118.6	143.3	302.9	308.8
Wednesday	165.5	182.2	320.9	325.0
Thursday	212.6	209.7	345.4	348.9
Friday	240.2	244.1	362.4	385.7
		Typewriting (Net Score)		
Monday	280.4	311.0	334.9	345.2
Tuesday	304.4	315.9	345.1	347.7
Wednesday	326.8	324.9	348.2	352.4
Thursday	329.5	335.8	346.5	351.9
Friday	332.4	335.9	352.9	350.3
		Addition (Net Score)		
Monday	61.6	66.5	88.8	93.6
Tuesday	73.0	76.9	94.2	96.7
Wednesday	79.9	81.7	96.0	98.9
Thursday	84.7	87.5	100.3	101.4
Friday	88.8	89.9	103.5	104.3

[16] Except in the case of Mental Multiplication when 21 were used.

The curves in the graphs so far presented are not exactly comparable in form, even within the same group of tests, because of the differences in the range of the various performances. In order to reduce each group of tests to the same scale the total ranges were equalized thus: For each test the total difference between the maximum and the minimum performance was taken to be 100 per cent. Then the difference between each point on the curve and the minimum performance was expressed in relation to the total difference between maximum and minimum score (or errors). That is, each point on Graphs III and IV represents the percentage of

GRAPH I


PRODUCTS
MIRROR TRACING
480
380
280
180
83.6
526.6
MENTAL MULTIPLICATION
350
250
150
57.4
385.7
TYPEWRITING
340
320
300
280.4
350.3
ADDITION
105
90
75
61.6
104.3
M
T
W
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F
M
T
W
Th
F

the total improvement reached up to a given time and the graphs as a whole express the distribution of the practice gains through the fortnight. The curves for each group of tests represent somewhat the situation we should have if several men had set out to walk. Each started at a different point and ended at a different point from the others but all walked for one hour. If for some reason we wanted to make their performances comparable we could only say that A had at the end of 15 minutes covered 10 per cent. of the total distance he walked, whereas B had covered 40 per cent. of his (B's) total distance and C 20 per cent. of his (C's) total distance. This would not tell us that B was the best pedestrian of the group but merely that he tended to walk fast in the first part of his trip. The misconceptions that can arise from the use of either

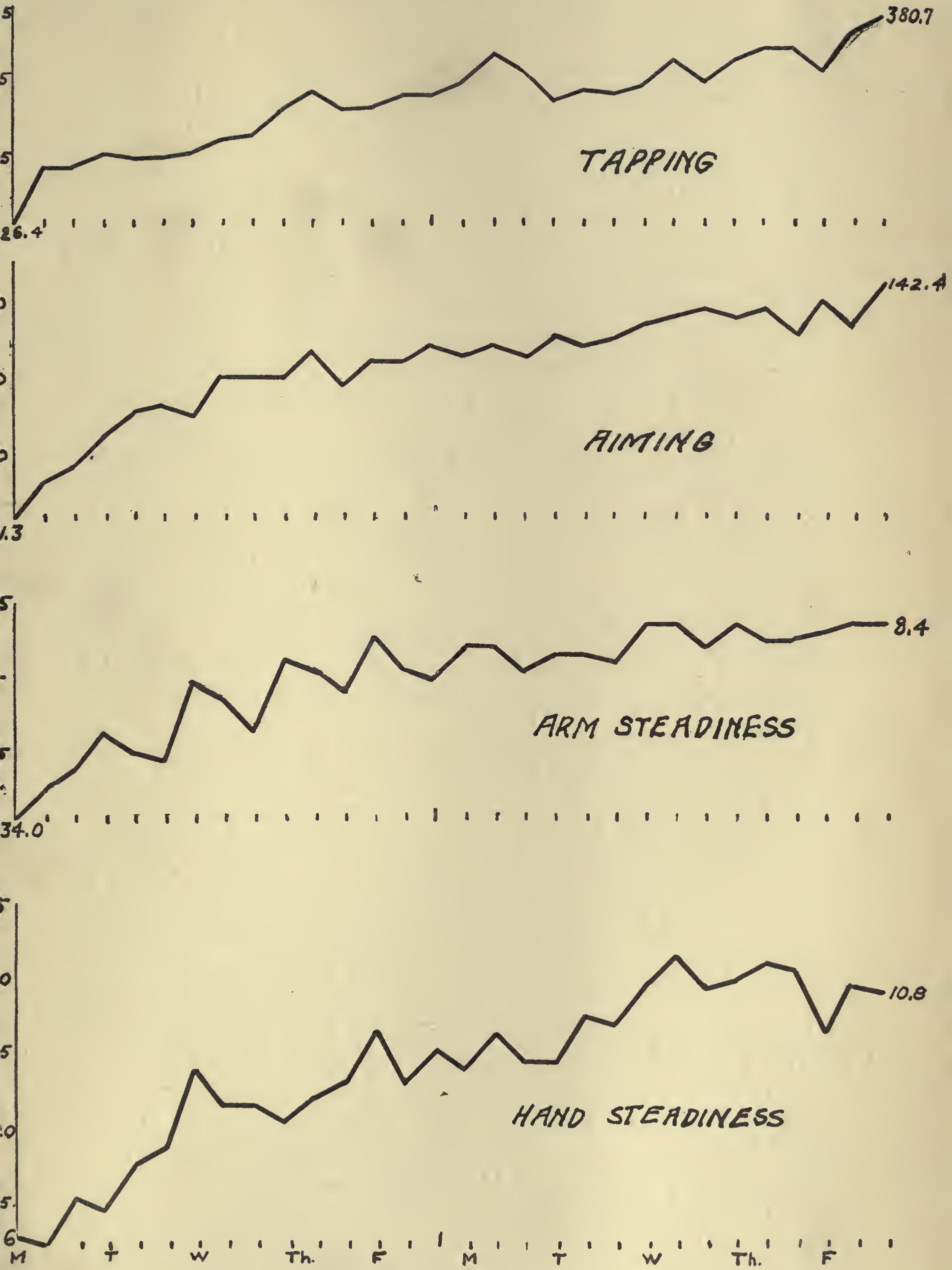
TABLE XVII

COMPOSITE PRACTICE CURVES

Each Figure is the Average of 22 Determinations.

	Week I			Week II		
	A.M.	*P.M.*$_{\text{I}}$	*P.M.*$_{\text{II}}$	*A.M.*	*P.M.*$_{\text{I}}$	*P.M.*$_{\text{II}}$
			Tapping (Net Score)			
Monday	326.4	340.9	340.7	364.2	372.4	366.9
Tuesday	345.3	343.9	343.5	359.0	361.8	360.5
Wednesday	344.9	348.8	349.8	362.9	369.6	364.4
Thursday	356.6	361.5	356.5	369.5	372.8	372.6
Friday	358.0	361.0	361.3	367.2	377.0	380.7
			Aiming (Net Score)			
Monday	111.3	115.6	118.1	132.8	134.4	133.3
Tuesday	122.4	125.0	125.8	135.4	134.0	135.2
Wednesday	125.4	129.5	129.7	136.9	138.1	139.0
Thursday	130.0	132.9	129.1	137.7	139.3	136.4
Friday	132.3	132.3	133.5	140.0	137.0	142.4
			Arm Steadiness (Errors)			
Monday	34.0	30.1	26.9	11.1	11.4	14.3
Tuesday	23.1	25.0	25.6	12.0	11.6	13.0
Wednesday	15.6	17.7	21.7	7.7	7.6	11.3
Thursday	12.7	14.3	17.1	8.1	9.5	9.5
Friday	10.0	13.5	14.8	8.7	8.2	8.4
			Hand Steadiness (Errors)			
Monday	27.6	28.2	24.9	15.8	14.0	15.5
Tuesday	25.4	22.5	21.4	15.3	12.5	13.2
Wednesday	16.4	18.6	18.7	10.6	8.7	10.5
Thursday	19.5	18.2	17.2	10.0	9.1	9.7
Friday	13.3	16.8	15.2	13.6	10.7	10.8

Graph II


380.7
26.4
TAPPING
142.4
1.3
AIMING
8.4
34.0
ARM STEADINESS
10.8
HAND STEADINESS
M
T
W
Th.
F
M
T
W
Th.
F

absolute or relative gain as a criterion of practice effect have been pointed out by many writers.[2] So long as no other interpretation is made of these percentile curves than the one just given their use here will not prove particularly dangerous.

We notice now that Graph IV brings out the previously noted convex shape of the curves for the motor tests, in which a large part of the total gain is made in the first week of practice. Considering Graph III we see that Typewriting resembles the first form of curve most closely; then comes Addition, and finally Mental Multiplication and Mirror Tracing, which are only slightly convex. The two graphs cannot be compared directly because of the difference in the length of the base lines. Nevertheless if the 20 points of Graph III be imagined as spread out over the space occupied by the 30 points of Graph IV, the group of tests appears to represent a continuity of stages from a fairly convex to a relatively rectilinear relationship.

The practice curve in the case of most of our tests has been rather thoroughly studied. The results for Tapping, Computation and Mirror Tracing are summed up in the revised edition of Whipple's Manual of Mental and Physical Tests; the results for Tapping, Addition, Mental Multiplication and Typewriting are further analyzed in Thorndike's Educational Psychology, Volume II.

Our observations on the shape of the curves are in substantial agreement with those of other investigators. The often-reported slow rise of the curve of Tapping has been carefully analyzed by Wells.[3] The special form of the Aiming test employed in our experiment was also used by Marsh[4] and by Hollingworth.[5] The curve of improvement cannot, however, be conveniently traced from Marsh's data as compensation has been made for practice. Even the records of Hollingworth's control subjects are plotted to give a series of curves for each one of five performances at successive periods of the day. According to this arrangement the initial rise of the curve, even after a week's preliminary practice, seems to last unduly long. If the records were combined to give a curve of three points a day the curve would probably be very similar to ours.

The characteristic convex shape of the Addition curve has long been known, though Chapman[6] got from college students a curve with a somewhat less rapid initial rise than usually appears. Our

[2] Thorndike, "Educational Psychology," II, 165–177.

[3] Wells, "Normal Performances in the Tapping Test," *Amer. J. Psych.*, 1908, 19, 437.

[4] Marsh, "The Diurnal Course of Efficiency," *Archives Philos., Psych. and Sc. Methods*, 1906, No. 7.

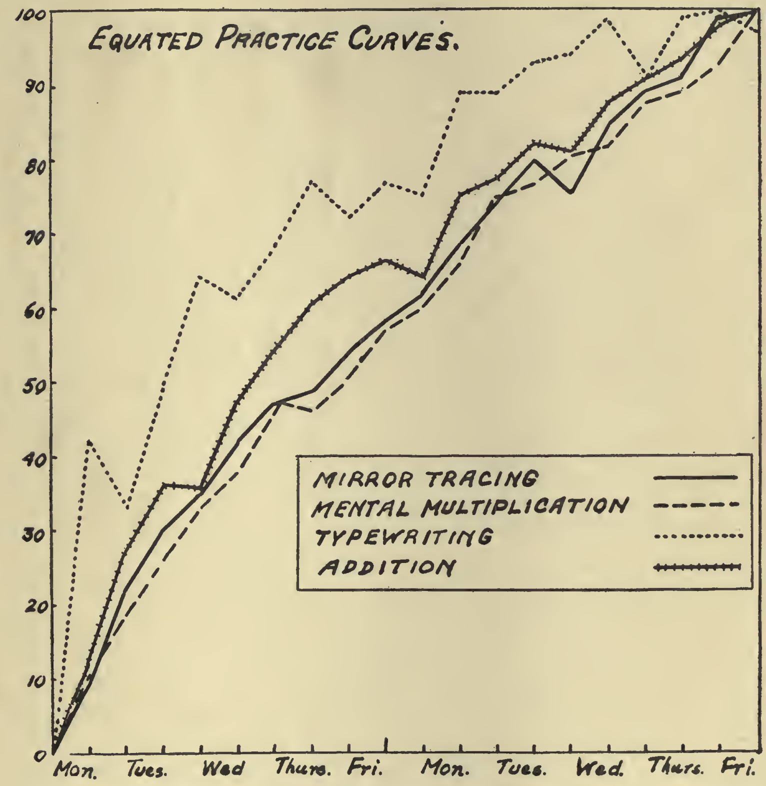
[5] Hollingworth, "The Influence of Caffein on Efficiency," *Archives of Psych.*, 1912, No. 22.

[6] Chapman, "Individual Differences in Ability and Improvement," *Teachers College, Columbia University, Contributions to Education*, 1914, No. 63.

curve for Addition, like Chapman's, shows no sign of flattening at the end such as has been found by Wells[7] with nurses and Thorndike[8] with school children. (Figs. p. 237 and p. 254, "Ed. Psych.," Vol. II.)

Our curve for Typewriting in a general way resembles curves given by Book,[9] although our subjects started with a considerable (unknown) amount of practice which brought them to a practice level earlier than was the case with Book's subjects.

GRAPH III



Our steep curve for Mirror Tracing corresponds to about one quarter of the long practice curve in which Starch[10] found a later slowing up, with maximum efficiency only after about 90 tracings of the star.

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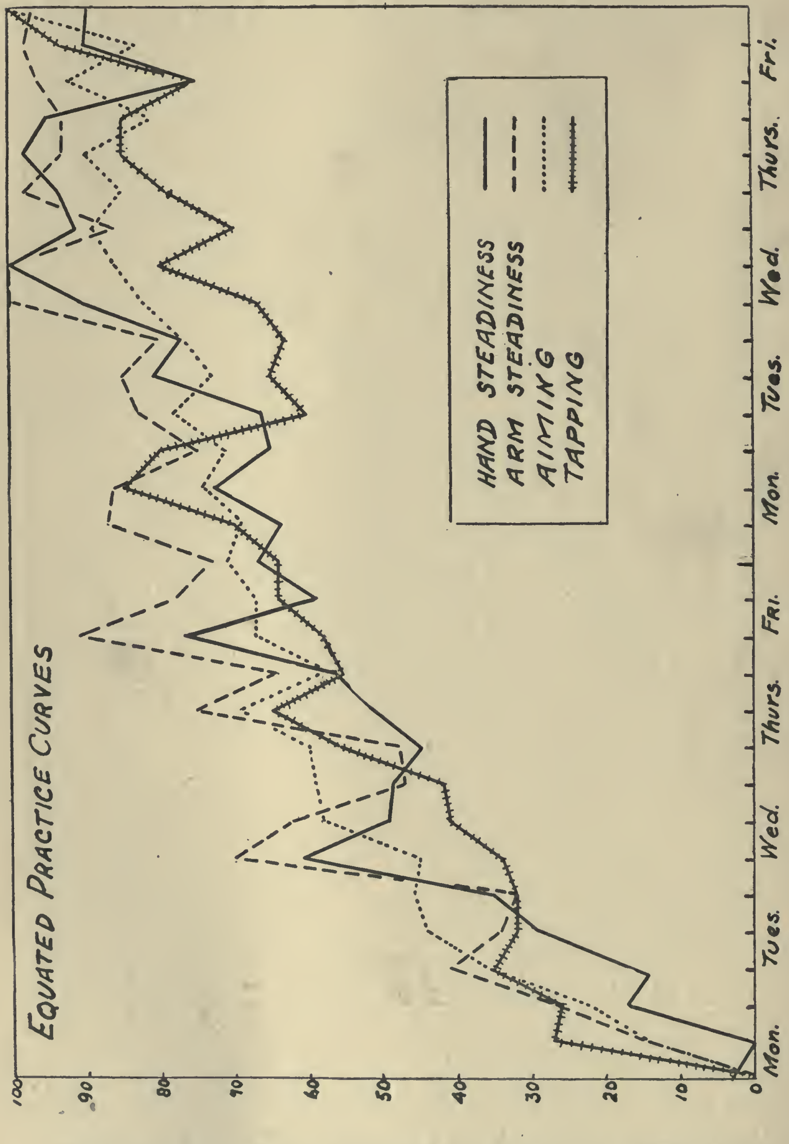
[7] Wells, "The Relation of Practice to Individual Differences," *Amer. J. Psych.*, 1912, 23, 75.

[8] Thorndike, "Practice in the Case of Addition," *Amer. J. Psych.*, 1910, 21, 483.

[9] Book, "The Psychology of Skill: with Special Reference to Its Acquisition in Typewriting," *University of Montana Publications in Psychology: Bulletin No. 53, Psychological Series No. 1.*

[10] Starch, "A Demonstration of the Trial and Error Method of Learning," *Psychological Bulletin*, 1910, 7, 20.

Graph IV



There appears to be no published account of the effect of long practice on the Hand Steadiness test. Such data exist in Hollingworth's records, but no comparison can be made at this time. An unpublished essay by Meylan also contains an account of a long practice series at the end of which subjects were able to hold the hand steady for several minutes without making any touches.

II. *Variations in Efficiency During the Working Day*

The previously noted variability in the motor performances lead us to inquire into the question as to whether these variations occurred with sufficient regularity to be taken as evidence for real fluctuations in efficiency during the course of the day's work. Our data, while totally inadequate for establishing the diurnal course of efficiency, did supply as an interesting by-product a certain amount of information about the relative effects of fatigue and practice under well-standardized conditions.

An examination of the foregoing tables and graphs shows that although in the group of more intellectual tests the subjects were making almost uninterrupted improvement throughout the two weeks, in the more simple sensori-motor tests, which were given three times a day, the subjects were nearing a practice level. A closer inspection of these curves in the second week of their course reveals the following facts:

Tapping.—While the P.M.$_{\text{I}}$ performance is on every one of the five days better than the A.M. performance, the P.M.$_{\text{II}}$ though better than the A.M. is worse than the P.M.$_{\text{I}}$ performance on four days. A considerable end-spurt on the last day of the experiment masks any fatigue that might naturally have occurred.

Aiming.—The matter is not very clear here. Three out of the five P.M.$_{\text{I}}$'s are better than the A.M.'s, and three out of the P.M.$_{\text{II}}$'s are better than the P.M.$_{\text{I}}$'s. The improvement of the P.M.$_{\text{II}}$ over A.M. is clear in only three cases. This vague tendency to improvement makes it seem unlikely that fatigue is strongly operative. It is perhaps significant that on Friday when the subjects started with a high score in the A.M. their score came down at P.M.$_{\text{II}}$ and went up again in a considerable end-spurt.

Arm Steadiness.—Three out of the five days show a better performance at P.M.$_{\text{I}}$ than at A.M., and four out of five days a worse performance at P.M.$_{\text{II}}$ than at P.M.$_{\text{I}}$, the fifth day being equal (which really means diminished efficiency because of failure to improve). In every case but Friday, where end spurt may be operative, the last performance of the day is worse than the first performance.

Hand Steadiness.—Every P.M.$_{\text{I}}$ is better than the A.M., and every P.M.$_{\text{II}}$ is worse than the P.M.$_{\text{I}}$, though better than the A.M. performance.

In order to study these differences further, a three-point curve was arranged for each of the four tests, *i. e.*, all of the second week data for all subjects was averaged for an A.M., a P.M.$_{I}$, and a P.M.$_{II}$ point (about 110 determinations for each point). Table XVIII presents these curves.

TABLE XVIII

VARIATIONS IN EFFICIENCY IN SECOND WEEK

Each Figure in the Average of 110 Determinations[11]

	A.M.	*P.M.$_{I}$*	*P.M.$_{II}$*
Tapping (Score)	364.54	370.80	369.02
Aiming (Score)	156.56	136.60	137.23
Arm Steadiness (Errors)	9.52	9.65	11.32
Hand Steadiness (Errors)	13.08	10.95	11.94

Considering the variations as brought out by these figures, we find that:

For Tapping, this method corroborates the findings of the day-method. Tapping starts low at A.M., and goes up at P.M.$_{I}$, and comes down again at P.M.$_{II}$, though not to the level of the A.M. performance.

For Aiming, this method agrees with the day-method in showing a slight improvement throughout the day.

For Arm Steadiness, this method agrees with the day-method in showing deterioration at the end of the day, but without the improvement in the middle of the day.

For Hand Steadiness, this method again strengthens the differences found by the day-method. The performance is worst at A.M., much better at P.M.$_{I}$ and slightly worse at P.M.$_{II}$.

It is obvious that such small differences as those found by either of these methods would fall well within the probable error of the average. The results are, moreover, still complicated by practice. They have therefore small validity of themselves, but are to be considered as corroborative of certain general tendencies traced by previous workers along the line of diurnal variations.

As early as 1892, Dresslar[12] found evidence of a diurnal rhythm in tapping, with a minimum at 8 A.M. and a maximum at 4 P.M. Marsh[13] has summed up the earlier work and added data on a variety of functions. In regard to his group of coordination tests requiring accuracy and speed of movement (Striking squares,

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[11] A.M. figures are the average of 109 determinations.

[12] Dresslar, "Some Influences Which Affect the Rapidity of Voluntary Movements," *Amer. J. of Psychology*, 1892, 4, 514.

[13] Marsh, "The Diurnal Course of Efficiency," *Archives of Philos., Psych. and Sc. Methods*, 1906, No. 7.

Snapping, Three Hole Aiming, Tapping) his conclusions are: "The thing most worthy of note . . . is the exceptional occurrence and decisiveness of the maximum tapping rate at 9–10 P.M. . . . The maximum of accuracy comes earlier in the day than the maximum of speed . . . ; there is no doubt that it falls somewhere in the middle portion of the day. . . . Tapping also gives a different diurnal course from other tests of speed, such as striking squares or writing numerals. In explanation of this difference it is suggested that rapidity of tapping, as it requires a minimum of control but a maximum of neural excitement, may be expressive largely of nervousness. If a person is most nervous in the evening, he would accordingly be quickest in tapping at that time, but not most accurate in motor control." Hollingworth,[14] working with Tapping, Three Hole Aiming, and Typewriting, found similarly that "mere speed showed a maximum at the end of the day, and speed with accuracy prescribed (Aiming) at the middle of the day." Hollingworth also found a general increase in Steadiness throughout the day, which is hard to reconcile with Marsh's theory that rapidity of tapping is indicative of nervousness, increasing as the day goes on.

In comparing these results with our own, it must be remembered that our working day was really only half a day; Marsh and Hollingworth gave records for test periods up to after 10 o'clock P.M. The time at which each of our three tests came was roughly:

	A.M.	*P.M.*$_{\text{I}}$	*P.M.*$_{\text{II}}$
Aiming	9:30	1:45	4:10
Hand Steadiness	"	"	"
Tapping	"	"	"
Arm Steadiness	10:15	2:15	4:15

Gates[15] has recently tested school children and college students with a number of tests (sensory motor, association, memory, etc.) and found evidence of a broad type of diurnal fluctuation in efficiency. According to him there is a steady rise from morning to midday. In the afternoon the motor processes continue to increase in efficiency while more strictly mental functions show an after-lunch decrease followed by a final increase in efficiency.

A brief comparison of some of our results with those of Hollingworth shows certain similarities. We found that Tapping starts low, goes up in the middle period and then comes down again. Hollingworth found Tapping to be rather a variable function as is shown by the following table of average time taken for 400 taps:

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[14] Hollingworth, "Variations in Efficiency During the Working Day," *Psych. Review*, 1914, **21**, 473.

[15] Gates, "Variations in Efficiency During the Day, Together with Practise Effects, Sex Differences and Correlations," *University of California Publications in Psychology*, 1916, **2**, 1. Gates, "Diurnal Variations in Memory and Association," *University of California Publications in Psychology*, 1916, **1**, 323.

Time of Day	10:30	11:15	12:00	1:30	2:15	3:00	3:45	4:15
Av.	49.8	49.2	47.8	47.7	48.0	48.3	47.2	47.9

It is possible that we both struck a point of increased efficiency at about 1:30 and a point of somewhat less efficiency about 4:15. We agree in finding improvement from A.M. to P.M. In regard to Hand Steadiness our records show a general improvement during the day, with a point of greater efficiency at 1:30 and a point of less efficiency at 4:15. Hollingworth's table for average number of contacts is:

Time of Day	10:30	11:15	12:00	1:30	2:15	3:00	3:45	4:15
Av.	15.0	15.0	14.6	12.0	14.2	14.2	13.8	12.7

It happens that as in our own results the 1:30 determination is again the best point on this part of the curve, and that the rise in efficiency which characterizes the latter part of the day has not gone very far by 4:15. The discrepancy between our course for Aiming (gradual improvement throughout the day) and Marsh's and Hollingworth's (maximum efficiency at Noon) is probably due to the persistence of practice in our experiment. A comparison of mental tests (which Hollingworth finds decrease in efficiency as the day goes on) and motor tests (which Hollingworth finds increase) is not possible from our study because of the practice effect. For the same reason our results for Mental Multiplication cannot be compared with those of Thorndike and Arai. In general our results should not be taken too seriously, as reliable information on the matter of such variations can only be obtained from a long series of tests in which many points on the day's curve are established.

CHAPTER VII

THE TESTS IN THE LIGHT OF EXPERIMENTAL EVIDENCE

CERTAIN general observations about the tests made by the experimenter or by the subjects themselves, as well as quantitative information more extensively reported in previous chapters may here be treated. In regard to the Addition test, it was interesting to see how much individuals who had had far more than an ordinary amount of practice improved as the result of a few minutes a day of intensive work under conditions of enthusiastic rivalry and interest in improving upon each day's record. The subjects approved the use of the two-minute work intervals and felt that they were stimulated by having their progress thus brought to mind. As the test has quite a high inter-group or reliability coefficient (.96) with the number of determinations made, an individual was pretty accurately measured.

The Three Hole Aiming test, performance in which had often seemed to the experimenter to vary rather unaccountably, nevertheless gave a fairly good coefficient of reliability (.93). The test measures speed, principally, except in so far as inaccuracy in not hitting the target directly, but sliding over toward the hole, increases the time taken for each hit. The correlation between Aiming and Tapping seems logical on the basis of a common speed element; but the lack of correlation with Typewriting, into which the same factors of speed and accuracy apparently enter, is quite unintelligible, especially in view of the fact that Hollingworth found Aiming and Typewriting to be similarly affected by caffein.

Tapping is a test peculiarly subject to end-spurt and other variations because of change in interest, rivalry, and so on. Our subjects regarded this test (and also Aiming) as a sort of race, with the sight of the counterhands moving around the dial, and the noise of the other subject's performance, acting as a spur to further achievement. During the first day the subjects sometimes had trouble in adjusting the height and the force of the tapping so as to insure the instrument's recording every tap, but soon overcame this difficulty. Notwithstanding the necessity of using this rather crude method of recording, the performance seems to have been as satisfactorily measured as in the case of Addition. The superiority of the P.M.$_{\text{I}}$ over the P.M.$_{\text{II}}$, if indeed it is a true one, could hardly be explained on the basis of interest, as enthusiasm for improvement was usually greatest at the "last-chance-for-the-day" trial.

The electric-counter method employed in the Steadiness tests gave a consistent measure of ability (.98 for Hand, .99 for Arm Steadiness) and was satisfactory for comparative purposes in the ventilation study. For an absolute measure of the degree of unsteadiness one would have to resort to greater refinements of method. In the Hand Steadiness test we found one or two individuals with a hand tremor so light and so rapid that the apparatus did not measure it accurately. In the Arm Steadiness test the hole was somewhat too large for very light touches to be recorded; yet the size could not be decreased much, because a constant noise of the counter recording errors would have thrown the subjects into utter confusion. The two tests, as we used them, do measure rather different things, which somewhat accounts for the indifferent correlation found.

In the Hand Steadiness test the subject was comfortably seated and had to control a rather small set of muscles to avoid movement in a horizontal plane. Irregularities in breathing, an eye movement, a start at the sound of the other subject's counter, or even a faint desire to laugh, resulting from the general strained situation, had a disastrous effect on the record. Since this was demonstrated to the subjects on the preliminary day, they were generally very cooperative in obtaining a true measurement.

The Arm Steadiness test seems to be more of the nature of a fatigue test. In the first place the subject was tested standing, and for two minutes rather than one, as in the Hand Steadiness. Then she held a long pointer which seemed very heavy before the end of the two minutes. There was, moreover, considerable eye-strain and adaptation during the course of the test so that the visual guide became less helpful, and the swayings of the whole body, as well as gross arm-movements, were recorded. This was shown in the appearance of circular movements of the arm, during which the tip of the pointer made a series of touches around a large portion of the hole. The test also measured movements in the sagittal as well as in the vertical plane. This differentiation between the two tests does not, however, hold in the correlations with other tests, as we have noted before.

The net score for our practiced subjects in Typewriting was quite constant (reliability .99). The relation between errors and speed has not as yet been worked out, but the records give one the impression that those who write fast also make many errors. Of course touch-writers are peculiarly liable to make errors unless they are very expert indeed. Here it must be said that the errors were mostly due to lack of fine adjustments in manipulating the machine, such as striking letters too close together, spacing in the wrong place, writing capital letters above or below the line, and shifting the entire hand out of its proper position on the keyboard. Other errors were of a more intellectual order, such as doubling letters, associating the proper finger with a letter but using the wrong hand, skipping, repeating, interchanging letters within a word, and forgetting to end a line as in the copy. Practically all the errors noted by Wells[1] in his fine analysis of the psychomotor mechanisms of typewriting occurred in our records. No more than 10 was ever subtracted for errors within the same line. Possibly the fast writers were unduly penalized in the use of a machine without a "back spacer." At any rate, the subjects were more interested in speed than in accuracy and the conditions of the test (four subjects typing at once) were rather conducive to haste.

The Mirror Tracing device, though requiring a good deal of care and polishing, was very satisfactory, as the slightest break of contact warned the subject of an error and produced an immediate corrective movement. Large excursions from the track never occurred. The small excursions might have been measured more accurately with a narrower strip and finer stylus, but it is doubtful whether the counter would have worked for a very much briefer break in the circuit. The reliability of the test is .96. A certain amount of variability in the performance resulted from conflicting ideals of speed and accuracy. To overcome this, the subjects were instructed to work for accuracy rather than speed, and were heavily penalized for errors. The test shows a negative correlation with Aiming, but resembles the other motor tests and also the intellectual tests. The use of the time-limit form of this test, in which several tracings can be made, seems a useful variation in technique for a long practice experiment since it allows the new habit to improve more steadily, permits of indefinite improvement and gives opportunity for a study of errors as fatigue progresses.

The extraordinarily low reliability of the Industrial Fatigue test (.24) may possibly be explained on the basis of variations in the speed of the rotating arm. It seems more likely, however, that in one trial a subject, having gone on for some time in an automatic manner, becomes careless, loses control of herself, and makes a large number of errors in her confusion, whereas in another trial by just a little more care she insures a perfect record. The subjects all complained of the monotony of the task and the accompanying eye-strain. Though the test is so largely influenced by chance, its correlations with all the motor tests but Aiming seem to be positive. With Wink and Tremor it is negative.

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[1] Wells, "On the Psychomotor Mechanisms of Typewriting," *Amer. J. Psych.*, 1916, **27**, 47.

Our use of the Mental Multiplication test gave but little new information. No attempt was made to prescribe a standardized method of doing the work but all methods were taught, and the subjects were allowed to use short cuts. In a way this is less desirable than having all the work done by the addition-of-partial-products method; still, unless one has subjects with an extraordinary amount of scientific conscience there is no guarantee that the work is being carried out by a harder method when a quicker one has suggested itself to a bright subject. A very satisfactory inter-group correlation resulted from this method (.99).

Considering now the Reflex Wink test, we found great individual differences in native capacity. Some subjects always winked when the hammer hit the glass, some never winked throughout the experiment, and some gradually ceased winking. Just what is the significance of the fact that a subject does not wink when nature intended that she should, is hard to tell. It may mean superior control, and it may mean greater insensitivity. As far as the ventilation experiment goes, this reaction does not seem to change under the air conditions studied. Partridge[2] found what he called "improvement in control" under the influence of alcohol, though this might equally well be called lessened sensitivity. He also found a gradual improvement in control in school children with increasing age. Swift[3] likewise found that a six months old baby did not wink, whereas it did begin to wink before ten months. All this seems to point to the possibility that the cessation of the reaction may be an undesirable thing, as is the diminution of the knee-jerk. Perhaps it would be better to change the sign of correlations with the Wink. At least this possibility must be borne in mind in interpreting our data. Whatever is being measured is definitely characteristic of the individual for the reliability is .99.

In regard to the observation of Eyelid Tremor, the experimenter felt that it was hardly worth while to use the five-point scale as only the extremes could be judged with any certainty. Individuals seemed to vary considerably on the middle of the scale and almost all, during the course of the experiment, showed improvement in keeping the eyelids from flickering. The reliability is lower than in the other tests (.90). The absence of tremor seems to be associated with a steady hand, speed in tapping and failure to react with a protective wink. As a general index of any but pronounced nervous disorder it has little value.

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[2] Partridge, "Experiments Upon the Control of the Reflex Wink," *Amer. J. Psych.*, 1899–1900, **11**, 244.

[3] Swift, "On the Origin and Control of the Reflex Wink," *Amer. J. Psych.*, 1903, **14**, 230.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

THE information obtained about Correlations, Practice and Diurnal Variations can not very conveniently be treated in a brief summary. This chapter will accordingly deal only with the main problem of the experiment. This study was undertaken primarily to investigate the supposed effect of air of low relative humidity upon nervousness as shown by defective motor control, and upon general inefficiency in work similar to that performed in daily life by clerks in offices and operatives in factories. Since tests can not be given often enough to obtain reliable measures of a changing condition without having the influence of the variables obscured by practice, the following device was adopted to balance out the practice effect. Subjects were tested in squads for a fortnight each. The first squad spent its first week under the wet, its second under the dry condition. The second squad spent its first week under the dry, its second week under the wet condition. For each test an average for performance in the wet weeks was obtained by adding the first week of Squad A and the second week of Squad B. A similar average for the dry weeks was obtained by adding the remaining weeks. By averaging the data from a number of squads, half of which were at the beginning, and half at the end of their practice curve, the practice was pretty well eliminated. Any remaining difference between the wet and dry averages might then be attributed to the ventilation condition.

Tests of:

Addition
Aiming
Hand Steadiness
Tapping
Typewriting
Arm Steadiness
Mirror Tracing
Industrial Fatigue
Reflex Wink
Eyelid Tremor

were given twice or three times a day in accordance with a fixed schedule, with 75° F., 50 per cent. relative humidity, and 75° F., 20 per cent. relative humidity as the air variables. In all of these tests the average performance computed as described above, and also the average improvement from the first to the last trials on any particular day, showed no reliable difference. That is, by these tests of nervous and motor control and by the more purely intellectual tests we could detect no influence of excessive dryness during two weeks' exposure or during the working day. While the physiologist would hardly expect any profound nervous deterioration from eight hours' or even two weeks' exposure, the advocates of high relative humidity in schools, offices, and other buildings claim to be able to detect the deleterious effect of dry air in even shorter time. The practical situation is that experimental humidity conditions considerably more rigorous than those obtaining in any artificially heated apartment show no demonstrable effect in behavior. Similarly, wherever psychological tests have been used in ventilation studies, the results have been negative.

Whether or not the subjects all put forth the same amount of energy or approached their maximum of effort matters little. The fact is that working quite naturally at what they regarded as a pleasant and not too strenuous job, they worked no less efficiently and showed no poorer control under excessively dry than under more favorable conditions. The argument that subjects are able by exerting extra effort to overcome uncomfortable conditions would not apply to the humidity experiment since the subjects did not feel uncomfortable, as is shown by their comfort votes. Moreover, any real physiological disturbance not reflected in the subjective feeling of comfort must have been detected in the objective determinations of pulse and temperature, which again gave negative results.

Still, our finding that individuals put under certain controlled conditions react or fail to react in certain ways is by no means to be taken as sanction for all sorts of uncomfortable ventilation conditions. It must be remembered that in isolating the factor of humidity, we did not attempt to reproduce the conditions that go to make up a crowded, ill-smelling and excessively hot room. The very fact that the method of ventilating the experimental chamber produced a normal amount of air movement tended to alleviate the discomfort that would ordinarily be felt in a closed room under a 75°, 20 per cent. condition. Nevertheless, previous experiments by the Commission have shown that behavior or product per unit of time is not affected by even more rigorous combinations of conditions. Whether this is due to a real absence of harmful effects, or to the marvellous power of the human organism to adapt itself to a changed environment, is at present still a matter of speculation. Psychology has given its answer, as far as it can in the present state of the science, to the question as to whether the ventilation conditions commonly found, have any effect on the practical activities of life. If this absence of demonstrable effect is due to a constant adjustment of the organism that will eventually result in strain, it is for physiology to trace any subtle, long-time ill-effects that may have escaped the behavior tests.

APPENDIX

INSTRUCTIONS TO SUBJECTS

I. *Directions for Addition Test*

YOU will be given (Printed side down) several sheets like this one.[1]

1

2	3	3	9	4	9	3	2	9	8	7	6	7	5	6	9
5	5	7	2	2	3	7	5	4	7	9	2	5	9	2	4
8	7	3	7	3	6	8	6	4	4	6	9	2	5	7	7
8	2	8	8	2	6	5	8	7	9	4	6	7	6	5	8
7	6	2	2	9	5	3	3	6	4	9	5	5	8	2	8
7	8	6	4	5	8	2	8	5	8	7	6	8	2	9	2
2	7	9	5	8	4	8	8	9	4	5	3	6	9	8	9
9	9	3	7	7	8	3	7	4	7	9	5	4	7	4	2
6	4	6	4	5	3	9	3	4	9	8	9	8	7	2	7
9	9	8	9	5	2	8	8	8	7	6	7	3	3	7	6

2	4	9	5	8	2	9	6	3	6	7	8	4	4	5	4
9	6	9	9	2	7	3	6	9	7	5	6	8	6	7	7
6	5	8	4	8	9	3	7	8	9	9	3	3	3	9	4
3	4	6	8	9	7	8	4	7	5	2	6	9	5	2	5
7	9	9	2	4	2	4	4	3	7	5	9	6	8	4	7
2	2	8	9	6	9	2	5	2	6	3	5	2	3	8	6
9	7	6	6	2	6	6	4	3	4	4	2	4	5	3	9
6	2	3	3	7	3	9	7	4	5	8	9	9	6	9	8
3	9	2	8	9	5	5	9	7	4	9	7	2	2	8	9
8	5	6	4	5	7	6	6	9	9	9	2	8	6	2	4

5	6	4	7	8	2	7	8	6	7	8	7	7	2	3	5
8	5	7	3	4	6	4	6	7	4	7	5	8	7	8	7
3	8	5	8	2	3	6	3	6	8	5	8	6	9	5	6
6	7	9	5	5	8	9	8	3	3	8	7	5	4	7	8
4	7	6	3	9	3	7	4	9	3	9	2	6	4	9	6
7	4	8	6	7	9	8	5	6	7	2	8	5	6	4	3
6	9	5	6	5	9	3	7	8	5	6	9	3	6	4	3
5	8	8	7	9	5	4	4	2	7	9	2	5	3	8	7
9	3	3	6	2	2	5	9	4	8	4	6	7	5	9	5
6	6	2	9	3	5	4	3	7	5	3	8	7	8	6	4

At the word "Ready" catch hold of the lower left-hand corner of the whole pile of sheets with your left hand, and take your pencil in your right hand. At the word "Go" turn over your sheets from the bottom, away from you. This will bring the sheets right side up. Beginning at the left-hand column of the upper row add these figures. Write the sum of each column of 10 figures as fast as you can, but without making errors. If any answer is wrong you will receive no credit for the answer in that column, but do not stop to verify or check up your answers. When you have finished one sheet go on to the next, putting the sheet you have just finished upside down before you. Work as fast and as accurately as you can until you hear the word "Mark." Then make a slanting line just where you are, and go on quickly with your adding. Do not let the sound of the word "Mark" cause you to forget the partial result you had in mind. Even if you are in the middle of a column make that mark where you are. I will say "Mark" every two minutes. When you hear the word "Stop," stop right off, turn over your sheets, write your letter and the date on every sheet you used. I want to find out how many sums you can do correctly in 10 minutes.

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[1] The type here differs in size and form from the original.

II. *Directions for Aiming Test*

The apparatus for this test is the inclined triangle at the left of the board. Take the stylus in your right hand, put your left hand on the board to hold it down and sit directly in front of the board. At the signal "Ready" hold the stylus point just above the upper hole and at the word "Go" put the stylus as rapidly as possible down into the bottom of the holes, one after the other, going around the triangle clockwise. As I say the word "Go" I will turn on the electric current, and after that every contact of your stylus with the metal at the bottom of the hole will ring up one hit on the counter. I want to see how many hits you can ring up in one minute, so I will turn off the current again after one minute and will then say "Stop." Keep on working hard until you hear that word. Keep your eyes on the work you are doing so you will be sure to get the stylus accurately in the hole. Do not watch the counter or your neighbor.

III. *Directions for Hand Steadiness Test*

The apparatus for this test is the inclined block at the right of the board. Take the stylus in your right hand, put your left hand behind you and sit in front of the block. At the signal "Ready" insert the point of the stylus a little way into the hole I will indicate to you. Hold the stylus like a pencil, and bend your arm as though you were going to write. Do not support your hand or arm in any way. Hold the stylus perpendicular to the plane of the block. Try to hold the stylus so steady that it will not touch the sides of the hole. At the word "Go" I will throw in the switch for the electricity. After that, every time you let the stylus touch the metal, you will hear the counter record one error. Try to make very few errors. At the end of one minute I will turn off the current. The test will be over when you hear me say "Stop."

IV. *Directions for Tapping Test*

The apparatus for this test is the brass plate in the center of the board. Sit down in front of the board with the right wrist through the tape binder and resting on the table lower than the board. Be sure to keep the wrist down on the table during the entire test. At the word "Ready" take the stylus in your right hand like a pencil. At the signal "Go" tap the metal plate with the stylus just as fast as possible. After three taps I will throw in the switch and you will see the counter working. Keep your eyes on the counter and tap hard enough to make each contact ring up on the counter. At the end of one minute I will turn off the current and then say "Stop." Try to see how many taps you can make in one minute.

V. *Directions for Typewriting Test*

Be sure that you are thoroughly familiar with the machine you are to use. Use only one method of typewriting throughout all the work you do here. In this test as in all others you are to work as fast as possible but without making mistakes. If, however, you do make a mistake do not go back to correct it, but continue copying. The material for you to copy is in these red books. (Thorndike, "Principles of Teaching"). Never copy headings at the top of the pages but copy such headings as occur in heavy type at the beginnings of paragraphs. Always begin work at the indentation of a paragraph which is marked with a number, and continue copying until you reach a place that is marked with a long line drawn horizontally across the page. Skip from that point to the next indentation of a paragraph which is marked with a number. At the word "Ready" you should be in position at the typewriter with your paper inserted and your copy open to the place you are to begin at. Keep your place from day to day but never begin a new test in the middle of a paragraph; instead go on to the next new paragraph. Never do over again a selection you have once copied in a test. Your score will be 10 for each line done with 1 taken off for each wrong letter or wrong space or wrong punctuation and 2 taken off for more serious errors. I will clap my hands twice as a signal for you to stop. When I do this stop at once without writing another letter. You will be given a few minutes to look over your papers at the end of each test.

VI. *Directions for Arm Steadiness Test*

The apparatus for this test is the block screwed on the wall. At the word "Ready" take the pointer in your right hand and with the finger-tips just touching the black line take your distance from the hole in the block. With the pointer held at arm's length and shoulder height, you should get the brass tip of the pointer just within the hole. Keep your eyes fixed on the hole. At the word "Go" I will throw in the switch and after that, every time your pointer-tip touches the sides of the hole or the metal at the back, the counter will ring up one error. If I see that you are getting the pointer too far forward so that there is danger of your pulling it out of the hole I will say "In." After two minutes I will turn off the current and say "Stop." Try to hold the pointer so steady that you will make very few errors.

VII. *Directions for the Mirror Tracing Test*

Take the stylus in your right hand and place your hand under the screen directly over the star. Fix the screen so that you can not see your hand directly but only by reflection in the mirror. At the signal "Ready" place the stylus exactly in the center of the strip forming the upper point of the star and at the word "Go"

VIII. *Directions for Mental Multiplication Test*

You will be given a number of sheets like this:[2]

New York Ventilation Commission

Name Date

					(1)	(2)	(3)	(4)	(5)
A.	Began	No. 1, hr.	min.	sec.	437	695	839	548	974
	Finished	No. 5, hr.	min.	sec.	93	73	43	63	34
					(1)	(2)	(3)	(4)	(5)
B.	Began	No. 1, hr.	min.	sec.	948	456	679	873	389
	Finished	No. 5, hr.	min.	sec.	74	36	48	69	89
					(1)	(2)	(3)	(4)	(5)
C.	Began	No. 1, hr.	min.	sec.	836	347	593	746	683
	Finished	No. 5, hr.	min.	sec.	76	94	48	38	84
					(1)	(2)	(3)	(4)	(5)
D.	Began	No. 1, hr.	min.	sec.	586	893	938	783	547
	Finished	No. 5, hr.	min.	sec.	69	36	49	76	97
					(1)	(2)	(3)	(4)	(5)
E.	Began	No. 1, hr.	min.	sec.	379	895	647	396	495
	Finished	No. 5, hr.	min.	sec.	78	67	34	96	47

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[2] The type and spacing here differ from the original.

begin to trace the mirrored star. Every time you get off the metal strip or lift the stylus from the metal you will hear a click and the counter will record one error. Keep on working until you hear the word "Stop." Then stop at once, but do not lift your stylus from the track until your record has been taken. Do not rest your hand on the board while you are tracing the star. Do not fail to cover every point of the star, making neat corners. If you get off the track come back on again immediately at the point where you left it. Your score will be the amount covered minus twice the number of errors. You are to work for accuracy rather than speed. At the word "Ready" catch hold of your sheets as you did in the addition test, and take your pencil in your right hand. Keep your eyes on your watch and at the word "Go" turn over your sheets and record in the proper spaces, the time at which you began. Then put your pencil on the table and begin to multiply the numbers of the first problem. The work is to be done mentally, nothing being written down until the entire result is obtained. The five figures of the result must be written down as fast as you can possibly write. Either keep your eyes closed or look at the example you are solving. Nothing is to be spoken out loud or whispered. You may work the examples in any way that is easiest for you, by the usual method of obtaining two partial products and adding them, by the method of multiplying by the first figure and adding in the obtained product as you multiply by the second figure, or by multiplying by both figures and adding in as you go along. This last method is the best and will enable you to do the largest number of problems when you know how to use it. Practice it according to this example:

$$\begin{array}{r}378\\ \underline{36}\end{array}$$

Multiply 8 by 6, which equals 48. Put down *8* mentally and carry 4. Multiply 7 by 6 which equals 42. Add 4 which equals 46. Multiply 8 by 3 which equals 24. Add 46 which equals 70. Put down *0* mentally and carry 7. Multiply 7 by 3 which equals 21. Add 7 which equals 28. Multiply 3 by 6 which equals 18. Add 28 which equals 46. Put down *6* mentally and carry 4. Multiply 3 by 3 which equals 9. Add 4 which equals *13*. The italicized figures which you in each case put down mentally are your answer: 13608.

Keep on working until you hear the word "Stop." Then record the time of ending, which should be twenty minutes later than you began. You are also to record the time of ending each set of five problems.

In all this work your aim should be to make the best possible score. The score is, of course, a composite of your speed and your accuracy, and will be kept as follows: The number of examples done in 20 minutes times 10, minus 2 for each wrong figure in the answer of each problem. That is, if all the figures in a five-place answer are wrong you get zero credit; if two are wrong, you get 6 credits, etc. You should therefore work carefully so as only very rarely to have errors in any answer.

IX. *Directions for Industrial Fatigue Test*

In this test I want you to pretend that you are a girl working at a machine in a factory. Your job will be to put these little cubes alternately on this inner square so that the edges just match. When I say "Ready" take one of the cubes in your right hand and when I say "Go" put this cube on the square. Then the arm will come along and sweep the cube off toward your left hand. You will catch it with your left hand, meanwhile putting the other block on the square with your right hand. If you should miss it, go right on as if nothing had happened. If the block falls down, pick it up and go right on. But remember every time you fail to put the block on, I shall count that 5 errors. The second thing to remember is not to let the rotating arm hit you,—and not to check its speed. Of course this machine will not hurt you, as a factory machine probably would. But if it does hit you I shall call out 3 errors. The third thing to remember is to get the cube exactly on the square. If you shove it over so that it touches one side of the outer square I shall call out 1 error. If it touches two sides of the outer square I shall call out 2 errors. I shall call out all the errors you make for my assistant to take down. At the end of five minutes I shall say "Stop." The machine goes fast, so keep your head and try not to make many of these errors.

X. *Directions for Reflex Wink Test*

Support your chin on the head rest and keep your eyes steadily fixed on some object on the level of your eyes at the end of the room. Look straight ahead of you. At odd moments when you are not expecting it, I will make the little hammer come up and hit the glass before your right eye. Of course this cannot hurt you, but at first you will wink at the sight and sound of the hammer. Now I want you to try not to wink when the hammer strikes. I will keep count of the number of times you are able to stop that wink.

CHRONOLOGY OF HUMIDITY EXPERIMENT

Squad A, Oct. 4–16, 1915.
Squad B, Oct. 18–29, 1915.
Squad C, Nov. 1–12, 1915 (Subjects 1, 2, 3). Began under Wet Condition.
Squad D, Nov. 15–27, 1915 (Subjects 4, 5, 6, 7). Began under Dry Condition.
Squad E, Nov. 29–Dec. 10, 1915 (Subjects 8, 9, 10, 11). Began under Wet Condition.
Squad F, Dec. 13–24, 1915 (Subjects 12, 13, 14). Began under Dry Condition.
Squad G, Jan. 4–14, 1916 (Subjects 15, 16, 17, 18). Began under Wet Condition.
Squad H, Jan. 17–28, 1916 (Subjects 19, 20, 21, 22). Began under Dry Condition.

PHYSICAL CONDITIONS IN THE EXPERIMENTAL ROOM[3]

	Temperature				
Date	*Dry Bulb*	*Wet Bulb*	*Relative Humidity*	*Cu. Ft. Air per person per minute*	*CO_2 parts per 10,000. Average A.M. & P.M.*
	Squad C.	*Week Nov. 1–6th.*	*Condition 78°, 50 per cent.*		
Nov. 1	75.0	62.5	50	31.5	5.5
2	75.0	62.5	50	30.5	4.7
3	75.5	62.5	48	30.0	4.2
4	75.0	62.5	50	30.0	4.7
5	75.0	62.5	50	30.0	4.5
Average	*75.0*	*62.5*	*50*	*30.5*	*5.0*
	Squad C.	*Week Nov. 8–12th.*	*Condition 75°, 20 per cent.*		
Nov. 8	75.0	56.5	29	35.6	5.0
9	75.5	60.0	39	31.0	5.0
10	75.0	57.0	30	30.0	4.5
11	75.0	56.0	27	31.0	5.0
12	75.5	60.5	40	31.0	6.0
Average	*75.0*	*58.0*	*33*	*31.7*	*5.0*
	Squad D.	*Week Nov. 15–19th.*	*Condition 75°, 20 per cent.*		
Nov. 15	75.0	60.5	42	30.0	3.2
16	75.0	55.5	26	31.0	5.0
17	75.0	55.5	26	30.0	5.2
18	75.0	55.0	25	31.0	5.5
19	75.5	61.5	46	30.0 Re-circ.	12.0 x
Average	*75.0*	*57.5*	*33*	*30.0*	*6.0*
	Squad D.	*Week Nov. 22–27th.*	*Condition 75°, 50 per cent.*		
Nov. 22	75.0	62.5	50	30.0	4.5
23	75.0	62.5	50	30.0	5.5
24	75.0	62.5	50	30.0	5.5
26	75.0	62.5	49	29.5	5.0
27	75.0	62.5	50	31.5	5.5
Average	*75.0*	*62.5*	*50*	*30.0*	*5.2*

x—Stagnant after 2.25 P.M.

---

[3] The maintenance of the physical conditions was in the hands of Mr. George T. Palmer and Mr. Philip Goldburg.

Date	*Temperature*		*Relative Humidity*	*Cu. Ft. Air per person per minute*	*CO_2 parts per 10,000. Average A.M. & P.M.*
	Dry Bulb	*Wet Bulb*			
Squad E. Week Nov. 29–Dec. 3. Condition 75°, 50 per cent.					
Nov. 29	75.0	62.5	50	25.0 (Leakage)	5.5
30	75.0	62.5	50	27.0 "	5.5
Dec. 1	75.0	62.5	50	27.5 "	5.5
2	75.0	62.5	50	27.0 "	5.5
3	75.0	62.5	50	27.0 "	5.5
Average	*75.0*	*62.5*	*50*	*27.0*	*5.5*
Squad E. Week Dec. 6–10. Condition 75°, 20 per cent.					
Dec. 6	74.0	55.0	27	27.0 (Leakage)	4.5
7	75.5	54.5	21	27.5 "	5.0
8	75.0	55.0	24	29.0	5.5
8	75.0	54.0	21	29.0	4.5
10	75.0	53.5	19	29.0	—
Average	*75.0*	*54.5*	*22*	*28.0*	*5.0*
Squad F. Week Dec. 13–17. Condition 75°, 20 per cent.					
Dec. 13	75.5	55.0	23	29.0	5.0
14	75.0	53.5	20	30.0	5.5
15	75.0	53.5	20	30.0	5.0
16	75.0	53.5	20	30.0	5.0
17	75.0	54.0	21	30.0	4.5
Average	*75.0*	*54.0*	*21*	*30.0*	*5.0*
Squad F. Week Dec. 20–24. Condition 75°, 50 per cent.					
Dec. 20	75.5	63.5	52	29.5	5.5
21	75.0	62.5	49	29.5	4.7
22	75.0	62.5	50	28.5	5.0
23	75.0	62.5	50	29.5	5.0
24	75.0	62.5	49	30.0	4.5
Average	*75.0*	*62.5*	*50*	*29.5*	*5.0*
Squad G. Week Jan. 4–8. Condition 75°, 50 per cent.					
Jan. 4	75.0	62.5	49	30.5	4.3
5	75.0	62.5	50	28.2	4.5
6	75.0	62.5	50	27.0	4.7
7	75.0	62.5	50	27.0	4.5
8	75.0	62.5	50	27.0	4.5
Average	*75.0*	*62.5*	*50*	*28.0*	*4.5*
Squad G. Week Jan. 10–14. Condition 75°, 20 per cent.					
Jan. 10	75.0	55.0	24	27.0	5.3
11	75.5	54.5	22	27.5	5.3
12	75.0	53.5	20	27.5	5.0
13	75.0	55.0	25	28.0	5.0
14	75.0	55.5	19	27.5	4.5
Average	*75.0*	*54.5*	*22*	*27.5*	*5.0*

Date	*Temperature*		*Relative Humidity*	*Cu. Ft. Air per person per minute*	*CO_2 parts per 10,000. Average A.M. & P.M.*
	Dry Bulb	*Wet Bulb*			
	Squad H. Week Jan. 17–21. Condition 75°, 20 per cent.				
Jan. 17	75.0	53.5	19	27.5	5.0
18	75.5	54.0	20	27.0	5.0
19	75.0	53.5	19	27.0	5.0
20	75.0	53.5	20	26.5	5.0
21	75.0	54.5	23	28.0	5.3
Average	*75.0*	*53.5*	*20*	*27.0*	*5.0*
	Squad H. Week Jan. 24–28. Condition 75°, 50 per cent.				
Jan. 24	75.0	63.0	51	27.5	4.5
25	75.0	62.5	50	25.5	5.5
26	75.0	62.5	49	27.5	5.0
27	77.0	65.0	51	27.5	4.5
28	75.0	62.0	47	28.0	5.7
Average	*75.5*	*63.0*	*50*	*27.0*	*5.0*

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THE MECHANISM OF CONTROLLED ASSOCIATION

BY

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ARCHIVES OF PSYCHOLOGY
EDITED BY
R. S. WOODWORTH

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THE MECHANISM OF CONTROLLED ASSOCIATION

INTRODUCTION

Preliminary Set: The Controlling Factor

Psychologists are accustomed to divide experiments in association into two main groups. First, the free association experiment in which the experimenter gives the subject a stimulus word and instructs him to respond with the first word suggested by the stimulus. Second, the controlled association experiment in which the instructions to the subject are to respond with a word standing in a previously defined relation to the stimulus word. For example, let us say that the stimulus word is *black*, the free association response would be the first word suggested to the mind of the subject, say, *cat;* but if the experimenter had previously instructed the subject to give *the opposite* of the stimulus word, then the appropriate response would be *white*. In this paper we shall refer to the word or phrase which defines the relation that the response bears to the stimulus by the term *task word* or *task words*.

The total time taken in a controlled associative reaction is divided into three periods. First, the *fore-period*, extending from the appearance of the task word to the appearance of the stimulus word; second, the *main-period*, extending from the appearance of the stimulus word to the response; third, the *after-period*, extending from the response to a few seconds after the response is given. This can be regarded as the gross mechanism of controlled association.

The general purpose of this paper is to study the processes involved in each of these periods—its primary purpose, however, is to analyze the fore-period. The hypothesis on which it proceeds is that the significant thing in controlled association is not what takes place between the stimulus and response, that is, in the main-period, but what takes place just before the stimulus is given, that is, in the fore-period.

It is by no means easy to find a word or a phrase that will adequately and unambiguously describe all the motor and mental processes involved in the fore-period. The Germans use the term *Aufgabe*. But this word is not free from ambiguity. Even in its restricted and technical sense it has at least four meanings. Professor Titchener[1] has pointed them out. "There are two gross meanings: (1) The problem set by the experimenter, the instructions given; and (2) the problem understood and actualized by the observer or subject. Of these, the latter is, I think,—as Dürr makes it,—the primary; and the original assumption was, I suppose, that the 'instructions' are always normal to the observer. Where that is the case, the Aufgabe as (1) is a sort of situational stimulus, which may be counted upon to touch off determining tendencies (or to set them up); as (2) it may be either the point of departure of determining tendencies or (by a natural transference) the sum of those tendencies themselves; and in either case it may be conscious or unconscious. So Aufgabe may equal, (*a*) instructions given by the experimenter, (*b*) preparation or preparedness of the observer, (*c*) intentions or purpose of the observer, and (*d*) 'idea of end' (or its equivalent) in the observer's mind." Since the term *Aufgabe* means something different to every writer who has used it, and since its meaning depends on the process or experiment to which it is applied, it is not advisable to use it here as a general term.

The word *set* has been used by Thorndike[2] and others as a blanket term covering all kinds of attitudes, adjustments, predispositions, preparations, and the like. I have adopted this term and shall use it in this paper in a general sense because its meaning seems fairly well established. But in order to indicate at the outset all that I understand it to include, I venture to propose the following schema:

$$\text{SET}\begin{cases}\text{General}\begin{cases}\text{Motor-adjustment}\\ \text{Mental-predisposition}\end{cases}\\ \\ \text{Specific}\begin{cases}\text{Motor-}\\ \text{Mental-}\end{cases}\text{Einstellung}\begin{cases}\text{`Task-set'}\\ \text{`Task-notion'}\end{cases}\end{cases}$$

Without stopping to justify this schema, I shall attempt an application of it to the problem of experiments on controlled association. Let us consider first *set in general.* The subject brings with him into the laboratory a certain mental predisposition; he is set to follow instructions and to perform the experiment as well as he can. In addition to this there are certain motor adjustments set up, as getting the eyes adjusted to the screen, getting ready to move the reaction key. All this can be described as *general preliminary set* and takes place before the experiment begins, and remains fairly constant throughout.

Considering next *specific preparatory set* we notice in the schema above that it is also both mental and motor. On the mental side it involves what I have called *task-notion* and *task-set.* By *task-notion* I mean the task words as understood or actualized by the observer; by *task-set* I mean the preparation or preparedness of the observer to respond when the stimulus appears. Task-set may be partly motor since preparation for a stimulus may involve certain motor factors. Thus, on the motor side, specific preparatory set may involve (1) a definite motor set or *Einstellung* and (2) certain motor aspects of the task-set. Taking both the motor and mental aspects together we may define *preparatory set* as a specific readiness to respond to a given stimulus according to a definite task.

---

[1] Unpublished correspondence.

[2] E. L. Thorndike, "Elements of Psychology," 1st ed., 1905.

The thesis to be defended in this paper is that preparatory set is the controlling factor in controlled association. To describe the mechanism of this set and to state the amount and kind of influence which it exerts on the associative reaction will be the aim of the following pages.

CHAPTER I

HISTORICAL STATEMENT

The Conception of Set Came Into Psychology from Experiments with Lifted Weights and in Reaction-time

In tracing the history of the doctrine of set it is quite unnecessary to go back of experimental psychology. Hobbes in his *Leviathan* has something to say about thoughts directed and thoughts undirected, but says nothing about a directing force or influence. Still further back psychologists and philosophers spoke of revery in contrast with directed thought; but to attempt to unravel this from the other threads of philosophy and metaphysics with which it is entangled would be an unprofitable task.

If we start with experimental psychology and look for the beginning of the notion of set, we find that it originated in two fields of experiments,—those with lifted weights and those in reaction-time. In the experiments with lifted weights, the investigators became interested in the process of comparison. In judging the difference or likeness between two weights it would seem that the subject would need to recall the first weight in order to compare the second with it. But Müller and Schumann,[1] Martin and Müller,[2] and Steffens[3] say that this is not the case, that no clear recollection of the first weight is necessary for judgment. What happens is that, when the first weight is lifted, it sets up some sort of motor adjustment, and the second seems heavy or light as it yields with difficulty or ease to the same force as was applied to the first. Other investigators have found that not only in lifted weights but also in other forms of comparison there is some sort of adjustment made by means of which comparison is possible. In the comparison of pitch, brightness, and other kinds of stimuli where motor adjustments cannot be assumed to be present, it has been suggested[4] that the process is the same except that the set is cerebral.

The general notion of the influence of set on a reaction came into psychology from the experiments in reaction-time. Wundt[5] first introduced the "ready signal" into the reaction experiment and noticed that when it is omitted the reaction-time is very much increased. Following this observation several experiments have been performed with a view to determining the length of the interval between the "ready signal" and the stimulus which will secure the shortest reaction-time. This interval in different experiments varies from one to two and a half seconds. Following this discovery the reaction period was divided first by Cattell into three sub-periods: (1) The fore-period, extending from the ready signal to the presentation of the stimulus; (2) The main-period, extending from the stimulus to the response; and (3) The after-period, extending from the response until a few seconds later. Upon analysis of the fore-period it was revealed that the most significant event in the whole reaction takes place in the fore-period, and that this event is the preparation or adjustment for the stimulus.

---

[1] Müller and Schumann, "Ueber die Psychol. Grundlagen der Vergleichung Gehobner Gemichte," *Arch. ges. f. Psychol.*, 1889, 14, 37ff.

[2] Martin and Müller, "Zur Analyse der Unterschiedsempfindlichkeit," Leipzig, 1899.

[3] Steffens, Laura, "Ueber die Motorische Einstellung," *Zeitschrift f. Psychol.*, 1900, 23, 241–308.

[4] Ladd and Woodworth, "Physiological Psychology," 1911, p. 602.

With the recognition of the fact that the preparatory set is the most important factor, and that the speed of the reaction depends largely on the amount and kind of preparation for it, certain investigators set out to vary this preparation to see what effect it had on the reaction-time. In 1888 Lange observed that the reaction-time is longer when the subject is set to observe the stimulus than when he is set to observe the response. Thus there arose the distinction between "sensorial" and "muscular" reactions; the sensorial reaction occurring when the subject is set to observe the stimulus, and the muscular reaction occurring when he is set to observe the movement made in response to the stimulus. More recent investigations have revealed that the object to which attention is directed is not the cause of the differences in reaction time. Ladd and Woodworth[6] have suggested that "in the sensorial attitude, the subject prepares, not only to react, but also to observe the stimulus; but in the muscular reaction, he does not prepare to *observe* the movement. Rather, he prepares to *make* the movement, and to make it as promptly as possible on receiving the stimulus." Thus the real difference between the so-called sensorial and muscular reactions is a difference in kind and complexity of preparatory set.

When we attempt to make the transition from simple reactions to associative reactions, we find the two not quite analogous in respect to the influence exerted by preparatory set. In simple reactions there are two important considerations: (1) The preliminary set, and (2) its influence on the reaction. In the case of associative reaction there are at least four things to be considered:

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[5] Wundt, "Physiol. Psych.," 5th edition, 3, 1903, 440.

[6] Ladd and Woodworth, "Physiological Psychology," 1911, p. 486.

(1) Preliminary set; (2) its influence; (3) the strength of the associative bond between the stimulus and the response; and (4) the amount of inhibition among the possible responses to the stimulus word. There is still another important respect in which the preliminary set is different in the two cases. In the case of the simple reaction one has a general set to react as quickly as possible to an already-known stimulus. The subject knows beforehand that the stimulus will be a sound or a light or a shock, and that he is to react by making a certain movement. In the case of the associative reaction the subject knows in a general way that the stimulus will be a word, and that his reaction must be another word standing in a previously defined relation to the stimulus. The stimulus and the response remain constant only within very broad limits. The set must necessarily be different here from what it is when both the stimulus and the response remain constant. This difference has to do with the different set which is peculiar to each task.

The history of the doctrine of set in its application to controlled association begins properly with the so-called Würtzburg or Külpe school of psychologists. The two important investigators are Ach and Watt. In 1905 J. H. Watt published a paper from the Würtzburg laboratory entitled "Experimentalle Beitrage zu einer Theorie des Denkens" and in the following year a paper of Ach's appeared, entitled "Ueber die Willenstätigkeit und das Denken," from the same laboratory. It is worthy of note, however, that neither of these investigators was interested in preparatory set (*Aufgabe*) for its own sake, and their results on this point were more or less by-products. Ach set out to investigate the will, while Watt was interested in controlled association. Thus Watt's work bears more directly on our problem than Ach's.

It was Watt who first recognized the preparatory set or *Aufgabe* as the important factor in controlled association. His chief contribution is summarized by Woodworth.[7] "The results of Watt's work may be summed up by saying that the task or problem or preparation or determining tendency or mental set,—or whatever it is best to call it, is less conscious and more efficacious than one would expect without experimental evidence. It is less conscious, for one would expect that it would be overtly present both when a reaction was being prepared for and when it was being executed. It is more efficacious, for one would expect that several reproductive tendencies would be awakened by the stimulus, and that the task would operate to select from among them; whereas, in most cases, no overt selection is necessary, since only the right reproductive tendency has been aroused. The selective influence of the task has

[7] R. S. Woodworth, Unpublished Lecture Notes, 1914.

been exerted *ab initio*, so that only what it selects appears. Though these results are not what would have been expected, they are easily verified in any kind of relatively easy controlled association."

Ach's chief contribution is what he calls "determining tendencies." Ach was the first to sub-divide the associative reaction period into the fore-period, main-period and after-period analogous to the division made by Cattell in simple reactions. He immediately recognized that the psychological processes most significant for the reaction take place in the fore-period. In the fore-period he found two processes present, the idea of end (Zielvorstellung) and the idea of object (Bezugvorstellung). The relation between the idea of end and the idea of object constitute a purpose or a resolve (Absicht). In a later work, "Ueber den Willensakt und das Temperament," 1910, he adds two more elements, namely, a "self" element, or an activity of self, and what he calls a "zuständliche" element, or a condition element. The idea of end sub-excites certain reproductive tendencies, and gives rise to the "awareness of meaning" which refers directly to the future ideas which are being made ready to cross the threshold of consciousness When these half-aroused reproductive tendencies are brought into relation with the idea of object they give rise to the "awareness of relation." Between the awareness of meaning and the awareness of relation there is an awareness that consciousness is controlled or determined by some factor. This awareness that "my" consciousness is being controlled or influenced in a certain direction is probably Ach's reason for introducing the "self" element and the "zuständliche" element.

These four elements constitute for Ach the purpose-consciousness or the resolve to act. It is the awareness that "I-am-ready-and-determined-to-act-in-a-specific-way." This resolve to act is the starting point of the determining tendencies which he defines as follows: "These dispositions, unconscious in their operation, which take their origin from the meaning of the idea of end and look toward the coming perception of object,—these dispositions that bring in their train a spontaneous appearance of the determined idea,—we call determining tendencies."[8]

Ach made another important contribution which bears more directly on our problem. He found that the time of the reaction was longer or shorter according to the degree to which the reaction is predetermined. If the instructions are specific and complete and the range of choice is narrowly limited the reactions are shorter than when the instructions are vague and indefinite and the range of choice is broader. He refers to this as the "Law of Special Determination."

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[8] Quoted from Titchener's translation, "Experimental Psychology of the Thought Processes," 1908, pp. 127–128.

In another set of experiments Ach attempted to measure the strength of the determining tendencies by requiring his subjects to memorize pairs of nonsense syllables, and later, after the bonds between each pair had been made strong, reading to the subject the first member of each pair and requiring him to respond not by giving the second member but by a syllable that rhymed with the first member. The object of the experiment was to see how many repetitions were required to form a bond between a pair of syllables that could not be broken by a determining tendency. The number of repetitions taken to do this was considered a measure of the strength of the determining tendency.

Messer[9] used the associative method in his studies on judgment and made some interesting observations on the influence of the *Aufgabe*. In the first place he thinks that the observer is liable to make the instructions more specific than they really are. This especially is true in "free-association" where the tendency is to give a "sensible reaction" rather than one which bears no relation to the stimulus word. Messer made a special experiment with two observers, instructing them to inhibit any response word that stood in a sensible relation to the stimulus word. Even here these observers found it difficult not to specialize the instructions. The logical conclusion here is that no associative reaction is possible without the operation, in some degree, of a determining tendency.[10]

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[9] A. Messer, "Experimentelle-psychologische Untersuchungen über das Denken," *Arch. f. d. ges. Psychol.*, 1906, **8**, 1–124.

[10] The above sketch is not an attempt to cover all, but only the most important, investigations bearing on preparatory set and its influence on the processes following it. Other experiments touching on it, though in a minor way are the following:

G. E. Müller, "Zur Analyze der Gedächnistätigkeit und des Vorstellungsverlaufes," *Zeitschrift f. Psych.*, **5**, I., 1911, 1–403.

E. Meumann, "Intelligenz und Wille," Leipzig, 1913.

A. A. Grünbaum, "Ueber die Abstraktion der Gleichkeit: ein Beiträg zur Psychologie der Relation," *Arch. f. d. ges. Psychol.*, 1908, **12**, 340–378.

A. Wreschner, "Die Reproduction und Association von Vorstellungen," *Zeitschrift f. Psychol.*, 1907–1909, **3**, 158 ff.

Margaret F. Washburn, "Movement and Mental Imagery," New York, 1916.

CHAPTER II

The Problem

To determine: (1) *The Nature of Preparatory Set,* (2) *The Kind of Influence which it Exerts on Associative Reactions, and* (3) *The Amount of this Influence.*

In the preceding chapter I called attention to the fact that the conception of set or *Aufgabe* is a by-product of the Würtzburg or Külpe school. Since the publications of the papers of Ach and Watt, I know of no investigation the primary purpose of which is to study the influence of set for its own sake. Many scattering facts have been gathered and much has been said concerning the importance of set in the psychology of judgment, comparison, thinking, association, and voluntary action, but no attempts have been made, as far as I know, to define *experimentally* the nature of set and its influence on associative reactions. Miss Washburn[1] has collected the experimental results in this field and has deduced from them a theory, or shown how they fit into her general theory of movement, but offers no verifying experiments of her own.

In general, my own problem is that of investigating preparatory set as the controlling factor in controlled association. In particular it is to determine (1) the amount of influence exerted by the set, (2) the nature of this influence, and (3) the nature of the set itself. In a certain sense the first of these problems has already been worked on by Ach in the experiments from which he deduced his Law of Special Determination. But my problem is different in this respect: Ach varied the instructions from vague and indefinite to specific and definite and noted the results on the association time; my problem is to keep the instructions constant and definite and vary the time allotted to the subject to get set.

Ladd and Woodworth[2] call attention to the fact that the length of an associative reaction is a measure of three factors: (1) The influence that the preliminary set exerts, (2) the strength of the bond between the stimulus word and an appropriate response word, and (3) the amount of inhibition between several responses any one of which is correct. Is it possible to determine the distribution of the time among these three factors? Or can we by a process of elimination get a measure of the first? We can eliminate (3) very well by using unequivocal associations, that is, by using tasks and stimuli to which there is but one response possible, as in opposites. But the task of measuring the time required for (2) is impossible. The strength of the bond between any stimulus and response involves so many unknown elements that it is hopeless to unravel them. If we wish, therefore, to know how much complete preparatory set facilitates an association, we must go at it in a more direct way.

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[1] "Movement and Mental Imagery," New York, 1916, ch. VIII.

[2] "Physiol. Psych.," p. 497.

But before the question of how much the *presence* or *absence* of preparatory set shortens or lengthens a reaction can be answered, it must first be determined whether or not any reaction at all is possible without some preparation for it. An empirical answer to this question will depend on whether or not experimental conditions can be created under which there is no preparation and still a reaction is obtained. At first glance one would suppose that the conditions offered by the free-association experiment would fulfil the conditions. But as I have already indicated, Messer and others found that even when the subject was instructed to inhibit all responses relating to the stimulus and to react with a nonsense reaction, it was impossible to prevent the operation of some unconscious determining tendencies. These and other observations have led to the conclusion that no associative reaction is possible without some degree of preparation for it. This being the case, the only thing left to do is to reduce the amount of preparation to its minimum with a view to determining, (1) what is the least preparation necessary to yield an association at all, and (2) what is the relation between the *time of preparation* and the *time of* the reaction. In order to accomplish this it is necessary to create conditions under which the observer will receive the minimum amount of preparation, and, with conditions as constant as possible, increase the amount of preparation until the minimum reaction time is reached. I have tried to do this by varying the length of the fore-period from zero up to about one second.

The second problem concerns the *nature* of the influence of preparatory set. There are at least three possible kinds of influence that the set may exert on the reaction. It may have (1) a facilitating influence, (2) an inhibiting influence, and (3) a combination of these two. Preliminary set may be said to have a facilitating influence when it operates to select a proper response from a number of responses that have appeared in consciousness, some of which are correct and some incorrect. In this case several response words compete for utterance, and the set or determining tendency simply serves to pick one out. That is to say, it facilitates the arrival of one into clear consciousness but does not inhibit the presence of others. The set may be said to have an inhibiting influence, and not facilitating, when it operates to prevent the appearance in consciousness of any responses except the right one. This right one simply comes up over the threshold *gradually and at its own initiative*, as it were, without being aided by any other influence. Here the task operates to inhibit wrong responses but not to facilitate the right one. The set may be said to have both kinds of influence when it operates to inhibit all responses except one, and that the right one, which it brings at once into the point of clear consciousness. This is the kind of influence that Watt described when he said that the task or *Aufgabe* exerts its selective influence *ab initio* permitting one correct response to appear. It is not to be understood that there are sharp lines dividing these three general kinds of influence, since it is entirely reasonable to suppose that there are all kinds of intervening shades and mixtures. Moreover, experiment may well reveal other kinds of influence than those outlined here.

The third problem, that of determining the nature of preliminary set itself, depends for its solution on an examination of the processes revealed in the fore-period. Here we are largely at the mercy of the observer's introspections. When we come to analyze these reports we shall ask (1) what are the psychological processes, and (2) what is their physiological basis?

CHAPTER III

THE METHOD

"Systematic Experimental Introspections" Checked by Objective Records

THE method used in this investigation is practically the same as that employed by Ach and Watt and by the Külpe school in general. Ach was the first to use it and gave it its name. Ach began his work in 1900 and presumably by the use of this method, although investigations had been carried on by the use of this method and had been published before Ach's paper appeared (1905). He named it "systematische experimentelle Selbstbeochtung" and carried it further than any of his colleagues by insisting on complete introspections from his subjects and by relying on these without the use of any objective checks. Watt was more careful at this point and took very accurate time measurements, but when he reported his results he put little emphasis on the time records.

This general method has been severely criticized by Wundt and moderately by Titchener. It is quite beyond the purpose of this paper to report the long discussion between Wundt and the members of the Külpe school at this point. It would take us still further afield to go into a defense of introspection in general. Furthermore, the objections of Wundt and Titchener are directed more against Bühler and Messer than against Ach and Watt. Yet at the same time the criticisms apply in general wherever the method of "systematic experimental introspection" is used.

The criticism of Wundt is, that it is theoretically impossible for a subject to *think* and to *observe* the process of thinking at the same time. He therefore proceeds to lay down four rules which any investigation must follow before it can deserve the name of an experiment. (1) The observer himself must determine the occurrence of the phenomena to be observed. (2) The observer must maintain an *observing attitude.* (3) Each observation must be repeated a number of times under identical conditions. (4) The conditions of the appearance of the phenomena must be determined by varying the circumstances. Granting that these four rules are the only guide for faith and practice in experimentation, my investigation will qualify as an experiment. But Wundt's objection is at best a theoretical one. It has been demonstrated in practice that mental note-taking of a thought in progress is entirely possible, a fact which Wundt admits. Titchener[1] asserts that although the introspection of a thought in progress is extremely difficult especially in the cases in which the experience is both complex and fleeting, yet "given a simpler experience, a slower movement of consciousness, it is altogether possible for report to keep pace with attention."

The objection of Titchener is that the subject commits the stimulus or *Kundgabe* error. That is, the observer does not describe his consciousness, but merely reports what it is referred to. Woodworth[2] has met this objection by pointing out that an observer must report his experience in one of three ways,—either in sensory terms, or in non-sensory terms, or in terms of the objects to which it is referred. If one rules out the last two, as the opponents to the method used by these investigators do, the only way left is to report the experience in sensory terms. And if the experience happens to be such that sensory terms are inadequate for description, as is often the case, there is nothing to say about it.

It seems to the writer that the strongest case against the method can be made on the ground that the members of the Külpe school needed more objective checks. The question is, when a subject reports that the movement from the stimulus to the response consisted of such and such conscious events, and that he observed two or three stages in the process, how is the experimenter to know whether these occurred before or after the response? In other words, what assurance is there that introspection is not a random, loose running, uncontrolled affair? This difficulty can be partly overcome by taking a careful and accurate time record of the interval to be introspected. I have attempted to do this and the results are satisfying. After I had classified the main-period introspections on the basis of the degrees of complexity of consciousness intervening between the stimulus and response, I found that the time increased as consciousness became more complex. For example, when the subject reported that nothing at all intervened between the stimulus and response the median time was one second; when images intervened it was 1.3 sec.; when a number of wrong responses came up and had to be inhibited the reaction time was 1.6 sec.

In order to determined more exactly the correlation between the complexity of a process and the time it occupies, I asked some of my subjects to score the interval between the stimulus and the response on an unlimited scale beginning at zero, and giving a score of 1 for each *conscious event*, defining a conscious event as one step in the process. For example, if a subject reported that there was a state of confusion followed by a feeling of hesitancy and that by an interval of waiting, the score would be 3. Of course this is a rough and ready way of getting at the problem and is beset with all kinds of difficulties. However, the correlations of these scores with the time records proved interesting. These correlations run all the way from .4 to .9 with a median at about .7 and all were positive. Owing to the fact that the score scale was so rough compared with the time scale, the resulting coefficients of correlation are very unreliable. Perhaps the most important thing about them is that they are all positive.

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[1] Titchener, *op. cit.*, 239.

[2] Woodworth, "A Revision of Imageless Thought," *Psych. Rev.*, 1915, **22**, 1–27.

Another objective check on introspection is that the reports admit of any classification at all. Throughout the entire investigation there were striking uniformities in the reports from different individuals. This was especially true of the fore-period. I found that the fore-period results could be grouped conveniently into six classes and the main-period results into eight. The very fact, therefore, that eight hundred reports taken from twelve subjects can be classified into so few groups is in itself a significant argument for the validity of the method.

CHAPTER IV

The Apparatus

A Device for Measuring the Length of the Fore-period and the Corresponding Main-period in Associative Reactions

Before the apparatus can be adequately described it is necessary to mention some of the requirements that it must meet. In the first place a number of different tasks must be presented in a random order and each task must change from reaction to reaction so that the same task does not appear twice in succession except by chance. In the second place it is necessary to have the exposure apparatus arranged so that the task word appears first, leaving the stimulus word still invisible, and so that the stimulus will appear upon the disappearance of the task words. For example, the subject must first see, say, the task words, *Give opposite of*, then after an interval, or when the subject is ready for the stimulus, these words must appear and the stimulus, say, *cold*, appear. In short, an exposure arrangement like this was needed:

$$1\begin{cases}\text{Give opposite of}\\ \text{cold}\end{cases}$$

$$2\begin{cases}\text{Give part of}\\ \text{clock}\end{cases}$$

$$3\begin{cases}\text{Give subordinate of}\\ \text{tree}\end{cases}$$

Each of these sections must appear one at a time and in a random order and the time that each remains visible must be taken.

A complete drawing of the apparatus is given in diagram I. It consists of five principal parts: (1) an exposure apparatus, (2) a timing device, (3) a time recording machine, (4) a voice key, and (5) a pendulum. I shall first describe each part separately and then explain how they were put together.

The exposure apparatus consisted of two brass drums D_1 and D_2 placed horizontally so that the distance between them could be adjusted to any desirable length. D_2 was made stationary and D_1 was left adjustable. The stationary drum, D_2 was propelled by a weight geared to it with two cog wheels. The control of the movement of the drum was effected by gearing the cogs up to an escapement taken from a Remington typewriter. This escapement is shown in detail in figure 3 of the diagram. To one side of the dog of the escapement was screwed an armature *am* of the electromagnet M_2 and to the other side of the dog the spring S was attached, so that when the current was made through the magnet it

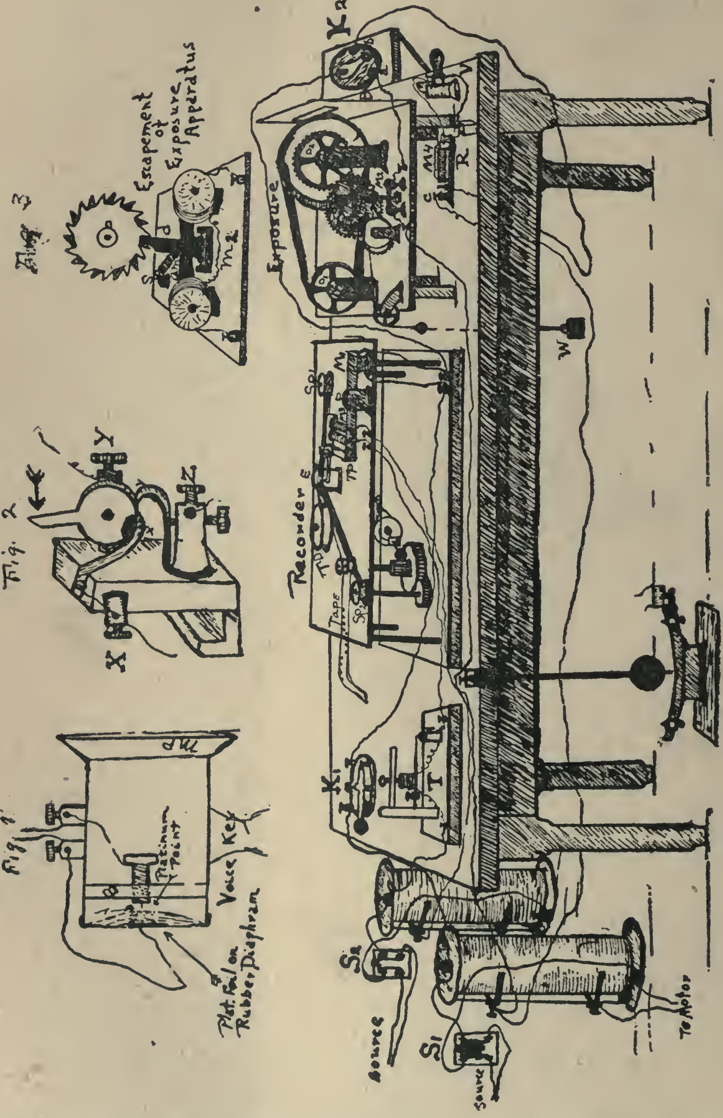


DIAGRAM I

pulled the dog over to one side and allowed the escapement wheel to turn one notch; then when the current was broken the spring pulled the dog back and allowed the wheel to turn another notch.

The first process, that of pulling the dog over by the magnet, exposed the task words, then the breaking of the current and allowing the spring to pull it back caused the task words to disappear and exposed the stimulus word.

The time was taken by means of the well-known vibrating reed apparatus. This is marked T in the diagram. It consisted of a steel reed about 15 cm. long with one end fastened securely to an upright bar about 7 cm. high and with a small wire attached to the free end which dipped into a mercury cup. Directly over the reed and about 3 cm. from the fastened end was an electro-magnet wired in the same circuit with the mercury cup and with the reed, so that when the small piece of wire on the free end touched the mercury it made a circuit through the magnet, causing the magnet to pull the reed up, which of course broke the circuit so that the reed went down again. By means of a small weight that could be placed in any position along the reed it could be made to vibrate as fast as 25 times a second or as slow as 5 times a second. By means of a stop watch, the reed was adjusted from time to time throughout the experiment to vibrate 20 times a second. Hence the unit of time in this investigation is 1/20 second.

The time was recorded on a Cattell ribbon kymograph propelled by a motor, the spring having been taken out. This is marked *Recorder* in the diagram. A two-color typewriter ribbon was used, would on spools Sp_1 and Sp_2. Directly under this ribbon, and at point marked *E* in the diagram, passed the ticker tape, which was wound around the spool marked *TD*. The machine was geared so that this tape passed over this point at the rate of one inch per second. An instrument was then arranged for tapping on the ribbon and making dots through the ribbon on the tape. This device is marked *TP*, and consisted of a small magnet M_3, the armature of which projected out about 5 cm., and was turned at right angles and pointed so that each make and break of the current through M_3 made one tap on the ribbon and hence one dot on the tape. The tapper magnet M_3 was then wired in series with the timer so that each vibration was recorded as one dot. Thus I had an instrument tapping twenty times per second, and the interval between each two consecutive dots on the tape represented a twentieth of a second.

The next problem was that of arranging this tapping device so that it would tap on the red side of the ribbon during the fore-period and on the black side during the main-period, thus giving a measure of the length of the fore-period in red dots and of the main-period in black dots. This was accomplished by mounting the whole tapping device on a pivot *P* so that the weight of the instrument would hold the armature down to tap normally on the lower or black half of the ribbon. Another larger magnet M_1 was placed below the free side of the pivoted tapper so that a current through this magnet would pull it down, throwing the armature on the upper or red half of the ribbon. M_1 was wired in series with M_2, the magnet controlling the escapement of the exposure apparatus, so that the two worked practically simultaneously. Thus when the operator pressed his key, K_1, and made the circuit, the exposure magnet exposed the task words and M_1 at the same time threw the tapper up on the red. When the subject broke the circuit by shifting K_2 from contact *a* to contact *b*, the stimulus word was exposed and the tapper dropped back on the black. Then the voice key was so arranged that speaking the response into it threw the tapper back on the red for a fraction of a second marking the end of the main-period.

The voice key is shown in detail in figure 1 of the first diagram. It consisted of a hard rubber tube about 9 cm. long and about 3 cm. in diameter. To one end was attached a glass telephone mouthpiece *MP*, and over the other end was stretched a light rubber diaphragm. In the center of this diaphragm and on the inside a small piece of platinum foil was pasted to which a wire was attached. About 1 cm. from the rubber diaphragm a brass bar was passed through the tube and in this bar was placed an adjustable screw. Normally the contact at *v* was made so that speaking into the tube broke it. The voice key was operated with one dry cell and this current was relayed to M_1 by the relay *R*.

I. *Arrangement for Experiment I.*—The entire machine was assembled as is shown in diagram I. The process of taking a single reaction was as follows: The subject is seated in front of the exposure apparatus and is instructed to look directly into the aperture of the screen with his hand on his key, K_2. He is further instructed to look at the task words when they appear until he is ready for the stimulus word, when he is to react by pushing the lever of his key from contact *a* to contact *b*, which process will expose to him the stimulus word to which he is to respond by speaking into the voice key. The operator then throws on the two main switches S_1 and S_2 which starts the kymograph, that is the recorder, running and at the same time starts the vibrator making black dots on the tape. The subject's key K_2 is over on contact *a* so that when the operator presses his key K_1 the circuit is made through magnets M_1 and M_2, working them simultaneously, thus exposing the task word and throwing the tapper upon the red side of the ribbon. He then responds by speaking into the voice key. His breath in speaking breaks the voice key circuit and releases the armature of the relay *R*.

This makes a contact at *c* completing the circuit through M_1, which throws the tapper up on the red, and so marks the end of the main-period. The operator instantly throws off the main-switches and stops the machine. The subject is then requested to give an introspective account of what occurred in each period. A sample record looks somewhat like this:

Red dots *FP.*

....

....

Black dots, *MP.*

II. *Arrangement for Experiments II., III., and V.*—In the first experiment the subject was allowed all the time that he desired in the fore-period, but in three other experiments the fore-period was arbitrarily limited. In order to do this the subject's key K_2 was removed and a pendulum installed. The pendulum is shown in diagram I., the wiring in diagram II., and the mechanism of the contacts in Fig. 2. A single reaction is now as follows (see diagram II.): The subject is, as before, seated in front of the screen. He is instructed to watch for the appearance of the task words which will come and remain for a certain interval (the subject is told the length

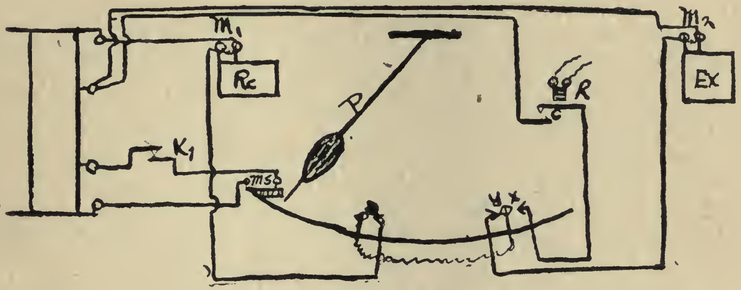


DIAGRAM II

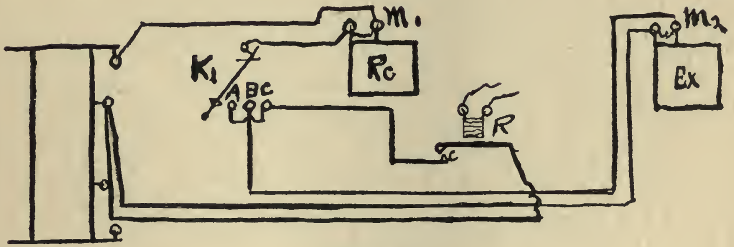
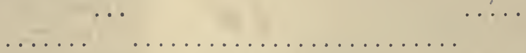


DIAGRAM III

of the interval) after which they will disappear, and the stimulus will follow immediately. Starting the machine as before with the two main switches, the operator releases K_1 breaking the circuit through M_5 which releases the pendulum P. The pendulum strikes the first post and makes the contact at z which completes the circuit through M_1 and M_2, simultaneously exposing the task words and throwing the tapper up on the red side of the ribbon. But when the pendulum strikes the second post (this post is drawn in detail in diagram I., Fig. 2) it breaks the circuit at y, releases magnets M_1 and M_2, and simultaneously exposes the stimulus word and lets the tapper drop back on the black ribbon. At the same time that the pendulum breaks the contact at y it makes a contact at x. This prepares the circuit through the voice key relay and through magnet M_1 but cuts out magnet M_2. The response in the voice key makes the contact at c completing the circuit through M_1, which throws the tapper back on the red. This indicates on the record the end of the main-period. The operator then stops the machine and calls for introspections.

III. *Arrangement for Experiment V.*—One other variation in the apparatus was required in order to reduce the fore-period to zero. To do this both the task and the stimulus were presented on one line. The wiring of the apparatus for this is shown in diagram III. The essential thing is that the operator's key had three contacts a, b, and c, the pendulum and the subject's key being removed. At the beginning of each reaction the operator's key was at either a or c. The line on the screen containing both the stimulus word and the task words was placed in the same relative position on the screen that the stimulus had been placed during the previous experiments. This necessitated an instantaneous make and break of the circuit, since it required a double escapement to expose this line. The passage of the lever of the operator's key over the contact b made and broke this circuit; but the contact remained made sufficiently long for the tapper to go up on the red and make one or two dots to indicate where the main-period began. This made the record look somewhat like this:



Reaction period.

CHAPTER V

The Technic

Five Experiments Performed, Twenty-Five Subjects used, About 6000 Reactions Taken

The Technic of Experiment I.—In the first experiment I used five tasks: (1) opposites, (2) whole-parts,—that is, to find a part when the whole is given, (3) part-wholes, —that is, to find the whole when a part is given, (4) subordinates,—that is, to give a subordinate part or concept of the stimulus, and (5) verb-objects, to give an object to a given verb. There were five stimulus words per task, making a total of 25 reactions per subject. The stimulus words were of about the same degree of difficulty as measured by Woodworth and Wells.[1] Fifteen subjects were used in this experiment. The reason for using so many was to attempt to settle a question of method which will be taken up in chapter VI.

This same experiment was repeated with the same subjects but with two important variations. In the first place a new set of stimulus words was used; and in the second place the tasks were presented in a different form. Instead of presenting the tasks in the form of sentences as was done in the first part of the experiment, they were presented in the form of samples of what to do; instead of saying, "Give opposite of," the task was merely suggested by "hot-cold." The following is a sample taken from an exposure sheet actually used:

Read from the bottom up

	Direct presentation		Indirect presentation
5	tree Give subordinate	5	grain— insect—bug
4	book Give part of	4	London— France—Europe
3	eat Give verb-object	3	sing— pump—water
2	empty Give opposite of	2	north— above—below
1	wing Give the whole of	1	pint— cent—dollar

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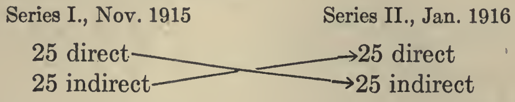
[1] Woodworth and Wells, *Association Tests*, *Psychological Monographs*, Dec., 1911, **13**, No. 5.

The object of presenting the tasks in these two different ways was to see how it affected the reaction. This will be discussed in greater detail later in the paper.

Two months later the two above experiments were repeated with the stimulus words reversed. That is, the 25 stimulus words that were originally presented with the direct tasks were presented to the same subjects with the indirect tasks and vice versa. So we have at the end of this experiment 50 stimulus words presented in two different ways to 15 subjects; each subject reacted to each word twice. This necessitated an arrangement of stimuli that would favor neither method of presentation. The following table will clear up how this was done.



We shall refer to this experiment as number I and the results are given in the two following chapters.

The Technic of Experiment II.—The essential thing about this experiment is the fact that the subject was not allowed all the time he wanted to get set, but the fore-period was arbitrarily limited by means of the pendulum described in the previous chapter. The length of the fore-period here was constant and limited to .15 of a second. The reason for making it .15 sec. was that I found this to be the shortest time in which the subject could read the task words. As a matter of fact this is below the reading time for many words but the subjects had seen each task ten times before in experiment I and had acquired all kinds of short cuts. It was not necessary here for the subject to read the task words to know what was wanted, the general shape of the words, the important syllables, etc., served to give him his clue.

In this experiment I introduced a new task, the supra-ordinate. It was presented, however, by the word *classify* which is more familiar than the word *supra-ordinate* and perhaps a little less ambiguous. I introduced this new task partly to get the effect of an unpracticed task and partly to be able to compare it with the subordinates; that is to see if there is any difference in the process of going from a higher to a lower and that of going from a lower to a higher.

For the present experiment I carefully selected sixty new stimulus words, ten for each task, half of which I presented directly and half indirectly. This made a total of 60 reactions per subjects for 15 subjects making a total of 900 reactions. But when I went to work up these results I found the variabilities of each subject so great that it was necessary to increase the number of reactions for statistical purposes. So I added 60 more stimulus words all of which were presented directly to ten of the fifteen subjects. This increased the total to 1500 reactions.

Systematic introspections were not taken in this experiment. From some of the subjects I asked for detailed introspections at unexpected intervals throughout the experiment and from others only a general description was required at the end.

The Technic of Experiment III.—In experiment III. the fore-period was lengthened to .35 seconds.[2] This experiment was like experiment II. in that the apparatus was arranged in the same way and that the fore-period was limited; it was like experiment I. to the extent that the same stimulus words were used as in the first experiment, but with ten fresh subjects. Here the tasks were presented in the direct form and 60 reactions per subject were taken.

The Technic of Experiment IV.—Up to this point I have described three experiments. In the first, the fore-period was determined by the subject himself and found to be .88 second on the average; in the second it was limited to .15 second; in the third to .35 second. Now in order to have a descending scale of fore-period from .88 to .35 to .15 to 00, a fourth experiment was added with no fore-period at all. Here the tasks and stimulus words were all presented on the same line, as *Give opposite of hot* or *Give part of hat.* Only ten of the original fifteen subjects were used.

The Technic of Experiment V.—The technic of experiment V. is exactly the same as that of experiments I. and III. except that the fore-period was limited here to .50 second. Ten subjects were used here, five old and five new. All the stimulus words had appeared previously in some of the above experiments. This experiment was made six months after the other had been completed.

In addition to these five major experiments three minor ones were made. But since I have not made use of the data resulting from them I shall not describe them here.

SUMMARY

Exp. No.	Subjects	Indir. reactions	Dir. reactions	Total
I.	15	750	750	1500
II.	15	375	1125	1500
III.	10		600	600
IV.	10		700	700
V.	10		600	600
Minor	10			1075
			Total	5975

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[2] The reason for placing the fore-period limit at .35 was to test a matter in experiment II. This will be made clear in the chapter on results.

CHAPTER VI

EXPERIMENTAL RESULTS

THE INTROSPECTIVE REPORTS

This investigation affords two kinds of data, (1) the introspective reports and (2) the time measurements of the reactions. Introspections from both the fore-period and main-period were taken and the time of each period was measured. The method of procedure here will be, first a treatment of the introspective data, then of the time data, and finally of the two combined.

All the systematic introspective records were taken from the first experiment. In this experiment I took introspections from every subject up to about 800 reports. At this point I found that the introspections were becoming repetitions and that the process was becoming more and more automatic so I resorted to the method of asking for introspections at unexpected intervals throughout the experiment and in some cases asked for general introspections at the end. As I have already pointed out I used three methods. Dividing my subjects into groups of fives, I closely questioned the first five, demanding detailed information concerning the mental happenings during the two periods; the second five were allowed to give what they could without being questioned or pressed for information; the last five were not asked to introspect at all during the experiment but were requested to give a general statement at the end.

An analysis of these data will throw light on the first two aspects of the problem, namely, (1) what is the nature of the preparatory set, and (2) what kind of influence does it exert on the reaction. I shall attempt to answer the first of these two questions from an analysis of the fore-period introspections and the second from the main-period introspections.

I. *Introspective Reports from the Fore-period*

The question here is, How did the subject get set? How much did the subjects differ in their ways of getting set? To what extent did the set to each task differ? Was there any difference in the ways of getting set to direct presentation of the task from the ways of getting set to the indirect presentation of the task? The differences here are sufficient to justify making a separate grouping for each method of presentation.

1. WAYS OF GETTING SET WHEN THE TASK WAS PRESENTED DIRECTLY.

(1) *Getting Set by Feelings of Direction, Tendency or Relation* (Marbs).—In a majority of the cases the subjects reported that the set consisted of some sort of feeling of direction or tendency or relation which can not be clearly classified under the ordinary rubrics of psychology. Some of these were reported as feelings of readiness or unreadiness, certainty or uncertainty, satisfaction, confidence, hesitancy, familiarity, etc. In many instances it took a specific kind of feeling for each task, like a feeling of *downwardness* for parts and *upwardness* for wholes, a *shrinking feeling* for subordinates and an *expansive feeling* for supra-ordinates. In other cases the subject represented each task by a kind of a formula, like a notion of *bigger than* for the task of *whole of*, and *less than* for the task of *part of*. These were not present in consciousness in the form of words or images but rather in the form of vague notions. I take it that this is the sort of thing that some members of the Külpe school called *Bewusstseinslagen* or attitudes of consciousness.[1]

Some of the most common marbs were confusion, readiness, and familiarity. Usually at the beginning of the experiment some subjects reported that the first noticeable thing in the fore-period was a state of confusion or absolute blankness. This seemed to last for some time and no amount of conscious effort cleared it up. The best policy seemed to be simply to let it clear itself up. In other cases the confusion consisted in confounding the part-whole relation with whole-part relation; the subject seemed to forget whether he was going from a lower structure to a higher or vice versa. The same was true of subordinates and supraordinates. In such instances the state of consciousness seemed to be best described as *confused*.

After each task had appeared once or twice most subjects seemed unconsciously to group them into hard ones and easy ones. When an easy one would appear the content of consciousness would be described as "that's easy" or "I can do this," or "go ahead." When a hard one appeared it was "look out," "take your time," "here is where I fall down." All this seemed to go on not in the form of words but in the form of vague meanings. The marb of *familiarity* was common to the latter half of the experiment. It consisted simply in a consciousness that this particular task has occurred before, that a set has already been established, and all that is necessary is to put on this particular shoe.

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[1] Professor Woodworth has suggested that since no satisfactory English equivalent has been found for the German Bewusstseinslagen, we call these processes "marbs" since it was Marbe who first called attention to them. I shall adopt this terminology in this paper and refer to them as marbs.

The marbs of *familiarity* and of *ease* were closely related. After the task had appeared a time or two most subjects reported that the only set required was the bare recognition of it and the vague memory that it had occurred before. But in case it had been a hard one on a previous occasion, or in case it had caused a false or bad reaction, the subject usually remembered the previous experience with it and determined to get himself set in such a manner as to avoid another mistake. Thus the marb of *familiarity* was coupled with one of *tension* or *strain.* When the hard task appeared the subject wondered whether he would succeed or make a blunder, in which case he usually hesitated for safety, making his fore-period abnormally long.[2]

(2) *Getting Set by Immediate Adjustment.*—After the task had appeared a number of times the *conscious processes* in the fore-period became very much abbreviated and gradually faded away. Watt called attention to this fact in his paper, and pointed out that the consciousness of the *Aufgabe* entirely disappeared. But Watt was not measuring the fore-period, and he was giving a whole series of stimulus words with a single presentation of the task. In such a case one would expect this to happen. But in my experiments where the task is changed with each presentation of the stimulus, one would hardly expect the consciousness of it to disappear entirely. Yet in many instances my subjects reported that even the marbs of *familiarity* and *ease* had disappeared. The set had become so well established that it took place immediately upon the perception of the task word. If we think of perception as a form of mental reaction, then the perception itself might be considered the set. The fore-period thus seemed to be reduced to the level of reaction-time; as soon as the subject saw the task, whatever it was, he was ready for the stimulus. It was hard for him to give an account of his mental happenings during the fore-period, since nothing had appeared above the threshold of consciousness.

(3) *Getting Set by Specific Motor Adjustments.*—To three or four subjects the set seemed to be distinctly motor. One observer

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[2] I am convinced that no one word will adequately describe the status of the subject's consciousness during this preparation period. The case is very complex and one usually gets a great mixture and a large variety of marbs. It is perhaps beyond the power of the most trained introspectionists to dissect these vague feelings and translate them into a language that would be understood by all. Yet the inevitable conclusion is that there are present in consciousness certain factors which cannot be included under sensations, feelings, or images, in the orthodox sense of these terms.

worked out a complete series of motor sets, one for each task. These sets were as follows:

For opposites	A movement of the head from left to right.[3]
For verb-objects	A movement of the head from right to left.
For whole-parts	A downward shrinking feeling.
For part-wholes	An upward expansive feeling.
For subordinates	A straight downward feeling.
For supra-ordinates	A straight upward feeling.

Each of these was sometimes accompanied by a kind of spatial figure or diagram. The subordinate figure was vertical lines running down to a point in space at a small angle; the surpa-ordinate figure was the same thing reversed; for part-wholes, the lines ran up from a point at a large angle; for whole-parts, the lines ran down to a point at a large angle; for opposites, parallel lines running to the right; and for verb-object parallel lines running to the left. These lines and angles and points in space were seldom reported as visual images. The subject insisted that they were neither visual nor motile but "just there in space." They were at first very marked and stood out clearly, but later faded out into marbs or vague feelings of downwardness, upwardness, shrinking, etc.

The subject who had the most elaborate series of motor sets worked out, reported that when each task appeared he made a conscious effort to put on its particular set, but the effort seemed to inhibit the process. If however, he merely allowed the set to put itself on, as it were, the process was much smoother and the reaction faster. He further asserted that these sets gradually lost their bodily or muscular aspect and became, as he termed it, "more neural." Later this neural process seemed to him to fade out into the non-sensory diagrams which in turn became reduced to marbs, then to an entirely automatic process. We have here a descending series of processes with the length of the fore-period getting shorter as the series descends

Another subject reported that he got an undifferentiated muscular set as a readiness to go in a given direction. He affirmed that this set was a muscular contraction with a readiness to expand at the instant the stimulus appeared. In other cases it was an expansion with a readiness to contract. All the time the set seemed to him to be entirely muscular and to consists in a particular definite motor attitude. Here again these motor adjustments wore down to more or less automatic processes.

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[3] James writes: "*There are certain quasi-motor sensations in the head* when we change the direction of the attention, which equally seem to involve three dimensions. If with closed eyes we think of the top of the house and then of the cellar, of the distance in front of us, and then of behind us, of space far to the right and then far to the left, we have something far stronger than an idea,—an actual feeling, namely, as if something in the head moved into another direction." "Psych.," Vol. II., p. 137.

(4) *Getting Set by Spatial Schemata or Diagrams.*—These spatial schemata are somewhat analogous to the second stage of the motor processes described above, but they differ in that the motor elements seemed to the subjects to be lacking. One subject's reports will serve to make this clear. His set for opposites was accomplished by the awareness of two points in space, one to the right and the other to the left. When the stimulus appeared it was located at the left hand point and with the coming response there seemed to be a movement over to the right hand point. These points in space were not visualized but were simply present there in front and outside. In some cases he reported that he seemed to nod his head from left to right and in other cases to move his hand from left to right, but the movements he could not be sure of. For the task of whole-part there seemed to be three lines running downward from the word *part.* These lines constituted the diagram in which he fitted the stimulus when it came and this aided a swift response. For the task of part-whole the diagram was simply one point in space which stood for the stimulus word and an awareness of an ill-defined region above and to the left of the point which represented the response. The subordinates were represented by two horizontal parallel lines cut by a transverse, the upper line standing for the stimulus and the lower for the response. These lines were not present in consciousness as lines or points but as vague notions of something above and something below, something to the left or to the right. After a few reactions these schemata also disappeared and the process became automatic. William James[4] finds something analogous to this in his own processes of reasoning: "In reasoning, I find that I am apt to have a kind of vaguely localized diagram in my mind, with the various fractional objects of the thought disposed at particular points thereof; and the oscillations of my attention from one of them to another are most distinctly felt as alterations of direction in movements occurring inside the head."

(5) *Getting Set by Key words of Syllables.*—A favorite way of some subjects in getting set was to pick out the significant word or syllable and carry it over into the main-period. The words and syllables usually emphasized were as follows:

For opposites	The syllable "opp."
For part-wholes	The word "whole."
For whole-parts	The word "part."
For subordinates	The syllable "sub."
For supra-ordinates	The prefix "supra."
For verb-objects	The hyphen between the two words.

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[4] James, "Psychology," 1, p. 300.

This process was carried out in various ways. Sometimes the word or syllable was simply emphasized or dwelt on while the other words and syllables remained in the margin of consciousness; sometimes all but the key word faded entirely and the subject reported seeing nothing but this. The methods of carrying it over into the main-period differed. Sometimes the key word was mentally pronounced and carried over as a word; sometimes it was translated into a figure or a diagram or motor set and carried over in this way.

In addition to these five ways of getting set there were several miscellaneous ones. One subject reported images and sensations; others translated the task words into questions; still others got adjusted by forming incomplete sentences. For example in the task *give a part of* the subject would say to himself "This (the stimulus word) is the whole of that (the response word)," or vice versa, "This response which I am to give must be a part of the stimulus." This sort of thing, however, occurred very rarely, since quicker and more efficacious processes were soon discovered.

2. WAYS OF GETTING SET WHEN THE TASK WAS PRESENTED INDIRECTLY.

It will be remembered that indirect presentation of the task refers to those experiments in which the task is given in the form of a sample of what is to be done. It is the proportion or "rule of three" method. The task consisted of two words standing in a certain relation. Among other things, *getting set* included comprehending this relation. The following are the principal methods used by the various subjects.

(1) *Getting Set by a Consciousness of an Undifferentiated Relation.*—Here the subject simply looked at the task words and got set immediately without seeming to be conscious of the particular relation of the two words. A large majority of these cases, however, belong to the latter half of the experiment in which the subjects were practised and well adjusted to the general task. A sample introspection runs like this: "I did not perceive any relationship at all between the two task words. I just stared at them for a moment and was set. All I experienced was a definite feeling of readiness." There is a great number of instances of this sort of thing, and I have interpreted them as a bare consciousness of an undifferentiated relation.

These introspections confirm in a striking manner Woodworth's[5] contention that "The feeling of relation may exist without the feeling of any pair of terms. . . Adjustment to a relation is not included in the adjustment to its terms, nor is consciousness of relation included in the consciousness of the terms."

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[5] R. S. Woodworth, "The Consciousness of Relation," in *Essays Philos. and Psych. in Honor of William James*, by his Colleagues in Columbia University, New York, 1908.

But the above introspections seem to carry the case even further than Woodworth carried it. Herbert Spencer and others who first recognized the consciousness of relation asserted that it could not exist without consciousness of the terms. Woodworth contradicts this and says that consciousness of relation is entirely possible without a consciousness of the terms. Here the case seems to be carried further since these observers assert that they are conscious of some sort of a relation but are not conscious of whether it is a part-whole, or whole-part, or subordinate, or opposite relation. Still they say that they get a definite set in the right direction. I have no reason for doubting this. To put it paradoxically it is a non-consciousness or an unconsciousness of relation.

(2) *Getting Set by a Consciousness of an Unnamed Relation.*—Here the subject was aware of a definite relation existing between the two task words; it was clear and well-defined, but not in the form of words, images, or spatial attributes. There are two important distinctions between this group of introspections and the one above. (1) Here the relation is differentiated; in the former case it was undifferentiated. (2) In the former case the subject was conscious of getting a set; here he seems to get no definite set. The bare consciousness of the relation seemed to be sufficient. Often he reported that he got a definite notion of opposite, part-whole, whole-part, etc., but the relation was not in words. The relation, therefore, that exists between the task words, was carried over to that between the stimulus and response without any apparent means of conveyance. As Woodworth suggests (see above), the adjustment in the fore-period is to the relation itself and not to the terms of the relation.

(3) *Getting Set by a Consciousness of a Named Relation.*—In this group I have classed the instances in which the relation was consciously and overtly named, as "opposite," "part-whole," "whole-part," etc. These names serve as ferry boats for carrying the fore-period relation over to the main-period. Sometimes a whole sentence like "I must give a part" or "I must give an opposite" was carried over. At other times the subject would first name the relation and then get his usual set which he had previously worked out for that particular task. The time for this process was really shorter than one would expect because these sets had already been worked out before hand in the previous experiment.

(4) *Getting Set by Conceiving the Relation in Spatial Terms.*—The relation that existed between the task words was sometimes trans-

lated into spatial schemata and carried over in that way. The usual method was to give each task word a certain spatial position with reference to the other word. The relative spatial positions of these two words was then carried to the main-period and the stimulus word was made spatially to coincide with the position of the first task word and the response word with the second task word. A sample is as follows: The task was "France-Europe" and the stimulus word "London." The introspection was, "In the fore-period I noted that France was *in* Europe and had a tendency to place it on a schematic map of Europe. When 'London' appeared, I knew at once that I must place it *inside* of something and that something would be the response. At that instant 'England' popped into consciousness."

Another way was to note the relative sizes of the objects represented by the task words and adjust the set accordingly. If the second word represented a smaller object than the first word, then the relation would be represented by a notion of "less than"; if the opposite were the case it would be "bigger than"; so that the response must designate a larger or smaller thing than the stimulus. In the cases of subordinate and supra-ordinate relations the space relations were usually up and down in the same plane, the response being above the stimulus for supra-ordinates and below it for subordinates. Sometimes these spatial relations took the form of vague geometric figures. To sum up we have the following kinds of spatial notions:

(*a*) The front-back, up-down, and left-right, and their opposite relations.
(*b*) The "bigger than" and "less than" relations.
(*c*) The inside-outside and outside-inside relations.

The front-back was most common in the task of opposites; the right-left and left-right, in verb-objects; the up-down, in subordinates; the down-up, in supra-ordinates; and the outside-inside and inside-outside, and the bigger than and less than, in part-wholes and whole-parts.

(5) *Getting Set by Motor Adjustments.*—This category is in part like number (3) under the direct presentation of tasks and in part like number (1) above. Here the subject got his set without naming the relation and in some cases without perceiving any relation. The bare perception of the task words seemed to set up an adjustment which was sufficient to yield a correct and prompt response when the stimulus appeared. In the case of the verb-object relation the set was most frequently described as a *feeling of activity* or a sense of *doing something to something;* in subordinates it was a *feeling of downwardness;* in whole-parts, a *shrinking feeling;* in

part-wholes, an *expansive feeling;* and in opposites, a *vague, balancing feeling.* All these will be recognized as about the same as those described under (3) in the section on direct presentation of the task.

(6) *Getting Set by Images in the Fore-period.*—In addition to the five ways of apprehending the relation between the task words, there was a number of cases in which the subjects reported images in the fore-period. It will be noted that I have avoided saying that the relation is apprehended in terms of images, since I am convinced that this is not the case. However, the subjects asserted that in some instances the image aided in the understanding of the relation. These images were seldom carried over into the main-period, and I shall later point out that when they were followed by an image in the main-period it was usually an image of something else. The set, therefore, does not consist of an image.

(7) *Getting Set by Repetition of the Task Words.*—Occasionally the subjects would resort to the method of simply repeating the task words a number of times. This was especially true when the relation seemed difficult. No definite set was realized except a kind of half conscious notion of the relation which came from constant repetition of the task words. Sometimes alliterations and rhymes were used as aids in getting prepared.

After these seven groups of introspections were made, there were left over a few cases that could not be fitted in. Some of these were premature reactions, some of them cases in which the subject got nothing in the fore-period and reacted without a set or a notion of the relation, trusting to luck.

3. Conclusions From Fore-Period Introspections; The Nature of Preparatory Set.

Before advancing any hypothesis concerning the nature of preparatory set, let us see if we can sum up in a general way the above mentioned ways of getting set and of apprehending the relation in the fore-period. Most of the subjects described or referred to two general processes in the fore-period: (1) A process of understanding the task, or of knowing what to do; (2) A process of getting set or ready to do it. The first of these processes corresponds roughly to Ach's "idea of end" (Zielvorstellung), and the second to his "determining tendencies." I have called the first *task-notions* and the second *task-sets.* In the beginning of the investigation, these two stood out very clearly but with practice they began to overlap, yet always remained somewhat apart. When the task was presented directly, the *task-notion* consisted in understanding and actualizing the problem, or the directions given in the task; but when the task was presented indirectly it consisted in apprehending the meaning of the two task words. The *task-set* consisted in ways of getting set in the first case, and in ways of apprehending the relation between the two task words in the second case. Thus variations from subject to subject and from task to task were slight in respect to *task-notions* but great in respect to *task-sets*. For this reason the above classifications were made on the basis of *task-sets*.

Some interesting observations follow from the distinctions between task-notions and task-sets. In the first place, it was found that when the task was presented indirectly there were groups of instances where one process seemed to be present without the other. Task-sets were present without task-notions in all those cases in which the subjects reported a consciousness of relation without any clear notion as to the meaning of the two terms between which the relation existed. The subject seemed to be conscious of a relation between the two terms without any definite awareness of the meaning of the terms themselves. Task-notions were present without task-sets in all the instances in which the subject was aware of the meaning of the terms without apprehending any relation between them. He carried the terms of the task over into the main-period by constantly repeating them, or by translating them into spatial schemata, or motor adjustments.

The validity of this distinction between task-notions and task-sets is not wholly dependent on introspective reports. In a later experiment I arbitrarily limited the fore-period to .15 second, partly with a view to determine whether or not the subject would get a task-notion without having time to get a task-set. The results of the experiment show that the time of the reaction is very much increased. In another part of the paper I have interpreted this increase as being due to the fact that the subjects in the fore-period did not have time to get task-set. I shall have more to say about this later; I merely mention it here to verify the genuineness of the distinction.

There are a few scattered passages in James's Psychology which indicate that he had picked out introspectively from among the many and complex mental phenomena, the thing that we are calling set. In the chapter on Attention and in the section called "The Intimate Nature of the Attentive Process" he mentions two processes which he calls "sensorial adjustment" and "ideational preparation." A few selected sentences from his text will serve to make clear the distinction between these two processes. Concerning sensorial adjustments he writes:

"When we look or listen we accommodate our eyes and ears involuntarily, and we turn our head and body as well; when we taste or smell we adjust the tongue, lips, and respiration to the object;

in feeling a surface we move the palpatory organ in a suitable way; in all these acts,— . . . , we inhibit others which might interfere with the result. . . . The result is a more or less massive organic feeling that attention is going on. . . . Any object, if *immediately* exciting, causes a reflex accommodation of the sense organ, and this has two results—first, the object's increase in clearness; and second, the feeling of activity in question."[6]

This "massive organic feeling" is, I suppose, due to the kinaesthetic sensations aroused by the movements of adjustments of the sense organ in question. He goes on to say, however,

"But in intellectual attention, as we have already seen (p. 300), similar feelings of activity occur."

The passage referred to on page 300 is as follows:

"In the first place, the acts of attending, assenting, negating, making an effort, are felt as movements of something in the head. In many cases it is possible to describe these movements quite exactly. In attending to either an idea or a sensation belonging to a particular sense-sphere, the movement is the adjustment of the sense organ, felt as it occurs. I cannot think in visual terms, for example, without feeling a fluctuating play of pressures, convergences, divergences, and accommodations in my eyeballs. The direction in which the object is conceived to lie determines the character of these movements, the feeling of which becomes, for my consciousness, identified with the manner in which I make myself ready to receive the visible thing. . . .

"When I try to remember or reflect, the movements in question, instead of being directed towards the periphery, seem to come from the periphery inwards and feel like a sort of withdrawal from the outer world. As far as I can detect, these feelings are due to an actual rolling outwards and upwards of the eyeballs, such as I believe occurs in me in sleep, and in the exact opposite of their action in fixating a physical thing. . . .

"In *effort* of any sort, contractions of the jaw-muscles and those of respiration are added to those of the brow and glottis, and thus the feeling passes out of the head properly so-called. It passes out of the head whenever the welcoming or rejecting of the object is *strongly* felt. Then a set of feelings pour in from many bodily parts, all 'expressive' of my emotion, and the head-feelings proper are swallowed up in this larger mass."[7]

These movements of which James speaks are perhaps the same sort of thing that my subjects described as feelings of *shrinking*, *expanding*, feelings of *downwardness*, *upwardness*, etc. I have

[6] James, "Psychology," 1, p. 435.

[7] James, 1, p. 301.

classed them as task-sets and have already pointed out their significance in the process of getting set. In a further comment on the significance of such adjustments James says:

"They are reactions, and they are primary reactions. Everything arouses them; for objects which have no other effects will for a moment contract the brow and make the glottis close. It is as if all that visited the mind had to stand an entrance-examination, and just to show its face so as to be either approved or sent back. These primary reactions are like opening and closing the door. In the midst of psychic change they are the permanent core of turnings-towards and turnings-from, or yieldings and arrests, which naturally seem central and interior in comparison with the foreign matters, apropos to which they occur, and holding a sort of arbitrating, decisive position, quite unlike that held by any of the other constituents of the Me."[8]

Turning next to James's "ideational preparations" he writes:

". . . The lying in wait for the impressions, and the preparation to react, consist of nothing but the anticipatory imagination of what the impressions or the reactions are to be. Where the stimulus is unknown and the reaction undetermined, time is lost, because no stable image can under such circumstances be formed in advance. But where both nature and time of signal and reaction are foretold, so completely does the expectant attention consist in premonitory imagination, that as we have seen (pp. 341, note 373, 377), it may mimic the intensity of reality, or at any rate produce reality's motor effect."[9]

After quoting copiously from Wundt, Exner, and Helmholtz in order to further illustrate his point, James finally concludes by saying that,

"The natural way of conceiving all this is under the symbolic form of a brain-cell played upon from two directions. Whilst the object excites it from without, other brain-cells, or perhaps spiritual forces, arouse it from within."[10]

This passage gives us a clue to the physiological mechanism underlying preparatory set. One might well wish that James had gone more into detail as to the way in which this brain-cell is played on from two directions. But back in the paragraph quoted on page 61 he speaks of the case where the ideational preparation is so strong that it "may mimic the intensity of reality, or at any rate produce reality's motor effect." Couple this notion of a certain area of the brain—or of certain of the neurones held in a nascent state of excitement, with the fact of summation of stimuli and one has the framework for a workable theory of the mechanism of preparatory set.

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[8] James, 1, p. 302.

[9] *Ibid.*, p. 439.

[10] *Op. cit.*, p. 441. My primary reason for quoting so freely from James is that these passages seem to strengthen my case. James is generally regarded as a master introspectionist and his introspective reports are usually correct. I regard it important that there is such a close resemblance between some of the introspective reports of my subjects and those of James.

The physiological processes underlying preparatory set might be thought of as consisting of diverging or distributing, and collecting or converging mechanisms. It is a well-known neurological fact that there are present in the nervous system certain groups of neurones whose function it is to collect impulses and another group whose function it is to distribute them.[11] It is not altogether unlikely that the same group of neurones possesses a double function, that of collecting and distributing. It is, therefore, nearer the truth to speak of divergence and convergence as *processes*.

The theory which I venture to propose is that task-notions have as their physiological basis certain distributing processes, and task-sets converging processes. That the neurological mechanism of controlled association is essentially a distributing one has already been mentioned by Ladd and Woodworth.[12]

"A word, taken in isolation, may suggest any one of many meanings; but in context it suggests only one. . . . Our question is, What cerebral mechanism corresponds to the context, and selects the proper path? It is not altogether impossible to reach a rough notion of such a mechanism. It would have the general character of a distributing mechanism, holding certain paths in readiness, and facilitating their action above those not so prepared. . . . If one says, 'Add!' for example, an adjustment is set up which favors the paths developed in learning the addition table; and the nerve-currents started by hearing two numbers in this context take this favored path."

I shall presume to amend this theory by making room for the "organic feelings" of which James speaks and which some writers[13] regard as processes essential to thinking. The question is, How are we to account physiologically for these feelings of *upwardness*, and *downwardness*, *shrinking* and *expansion?* Introspectively they seem significant and this perhaps is our only reason for including them in our physiological account of the mechanism of controlled association.

Accepting the theory of "higher units" as a working hypothesis and assuming that these "higher centers" have the double function of distributing and collecting impulses, we have little difficulty in assigning the distributing mechanisms to task-notions and the collecting mechanisms to task-sets. That task-notions have as their physiological correlates diverging processes has already been alluded to. Task-notion or the understanding of the task words *as a task* (when the task is presented directly) and the apprehension of the relation between them (when it is presented indirectly) is analogous to what Ladd and Woodworth refer to as the understanding of a word in context. A word in context has one meaning and in isolation many because the cerebral mechanism corresponding to context is supposed to be a distributing mechanism holding certain paths in readiness. Likewise, when the subject reads the task words he understands them *as a task* because they excite a distributing mechanism and the paths leading out from it are held in a state of sub-excitement.[14] This is all that is necessary to yield a reaction, but not sufficient to yield a speedy one. For these sub-excited paths are many and there is still room for conflicting responses. Moreover, it is conceivable that there are degrees of sub-excitement ranging all the way from zero to a tingling sense of readiness.

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[11] Ladd and Woodworth, *op. cit.*, pp. 159ff and 622. Sherrington, "Integrative Action of the Nervous System," 1906, Lectures I. and V.

[12] Ladd and Woodworth, *op. cit.*, p. 624.

[13] Bain, Ribot and Lange. See references cited in James, 1, p. 444.

That task-sets have as their physiological correlates collecting or converging mechanisms is not quite so obvious. A little while ago we quoted James as saying that "Where both the nature and time of the signal and reaction are foretold, so completely does the expectant attention consist in premonitory imagination, that . . . it may mimic the intensity of reality, or at any rate produce reality's motor effect." How does this come to pass? The paths which the distributing mechanism holds in readiness are presumably those motor paths leading to the vocal cords. The action of these paths is inhibited until the stimulus arrives which sets certain of them in action. In addition to holding in readiness these paths leading to the vocal cords, the distributing centers also shoot out impulses into other motor pathways producing certain muscular and visceral movements. These movements send back to the brain different impulses which produce the kinaesthetic sensations of *shrinking*, *expansion*, etc. It is possible that these sensory impulses impinge on the distributing mechanisms in question and heighten the sub-excitement of the paths leading out from them and thus give the subject *a feeling* of *readiness*. It is also possible that they impinge on certain of the sub-excited paths and not on others and thus aid in the prevention of a conflict in possible responses. In the first case their function might be called informational since they inform the distributing mechanism that the impulses sent out have been strong enough to produce certain bodily movements and are therefore of sufficient strength to set off the vocal cords. In the second case their function is reinforcing since by the law of summation of stimuli they heighten the state of excitability of one of the ready paths and thus facilitate a quicker response.

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[14] James, *op. cit.*, 1, pp. 433 and 527. Ach, "Ueber die Willenstätigkeit und das Denken," 1905.

Another possible function of these movements or tendencies to movements is also suggested by James:

"It is a well-known fact that persons striving to keep their attention on a difficult subject will resort to movements of various unmeaning kinds, such as pacing the room, drumming with the fingers, playing with keys or watch-chain, scratching head, pulling mustaches, vibrating foot, or what not, according to the individual. . . . Now much of this activity is unquestionably due to the overflow of emotional excitement during anxious and concentrated thought. It drains away nerve-currents which if pent up within the thought-centers would likely make the confusion there worse confounded. But may it not also be a means of drafting off all irrelevant sensations of the moment, and so keeping the attention more exclusively concentrated upon its particular task? . . . A downward nerve-path is thus kept constantly open during concentrated thought; and as it seems to be a law of frequent (if not universal) application that incidental stimuli tend to discharge through paths that are already discharging rather than through others, the whole arrangement might protect the thought centers from interference from without."[15]

Miss Washburn (if I understand her correctly) is on the track of the same thing when she says:

"The problem idea (Aufgabe) becomes the starting-point of effective and directed thought towards its solution only when the incipient motor innervation which the problem involves connects itself, not simply with general restlessness and uneasiness, but with the steady innervation of the activity attitude."[16] Her "incipient motor innervation which the problem involves" is somewhat analogous to my task-notion, and her "steady innervations of the activity attitude," to my task-set. She says, further, that the activity attitude is revealed in introspection as "feeling of effort" or "feeling of activity." My subjects seemed to be able to go further and locate the "feeling of activity" as upward, or downward, or shrinking or expansive, etc.

Another salient fact of this investigation is the one mentioned by

[15] James, 1, pp. 457–458.

[16] "Movement and Mental Imagery," 1916, p. 161.

Watt, namely, that the preliminary set continues to have its influence when it has dropped out of consciousness. In the first two sections of this chapter where I classified the various ways of getting set, I continually referred to the fact that these various methods were not employed by any one subject all the way through the experiment so far as he could observe, but, as the experiment progressed and as the observer became practiced, the process of getting set became more and more automatic. The subject is no longer able to distinguish between task-notion and task-set, nor is he conscious of going through any process of getting set. He seems to be ready for the stimulus as soon as he sees clearly the task words. But in all these cases "the activity attitude persists," in the sense that the subject must always be alert with attention active. But it seems to me that the real explanation lies in the fact that with practice two things happen. (1) The diverging pathways leading out from the distributing centers become more open and are less dependent on reinforcement from the converging pathways; and (2) the bodily movements drop out because the impulses which at first overflowed into their motor pathways, are now drained off in the paths leading out from the distributing neurones. Nevertheless there remains a certain amount of convergences probably from other sensory centers in the brain which were the receiving stations for these different impulses from the body.

The theory here presented does not claim finality in any sense of the word. It does not claim to be worked out in detail, nor to cover all of the facts. It is merely a suggestion as to how the facts of this investigation might be accounted for. Any attempt, however elaborate, to picture the complexity of any mental process in physiological terms is beset with all kinds of difficulties.

II. *Introspective Reports From the Main-period*

In the analysis of the introspective reports from the main-period we hope to throw some light on the second question of the investigation, namely, What is the kind of influence which preparatory set exerts on the associative reaction? In classifying these reports it is necessary to keep in mind the purpose for which the classification is made. The method of classification used here is an arbitrary one, and is designed with a view to making certain facts stand out. The principle of grouping is both quantitative and qualitative. That is, these data are classified on a basis of the *kind* and *amount* of conscious events intervening between the stimulus and the response.

1. Conscious Events Intervening Between Stimulus and Response When the Task was Presented Directly

(1) *Nothing Intervening: the Process Automatic.*—About one half the time the subjects reported that they were unable to observe anything at all intervening between the stimulus and the response. The response seemed to follow immediately upon the perception of the stimulus word. These cases were most common when the reaction was unique, that is, when there was only one possible response. However, this sort of thing occurred many times when the responses were unequivocal, that is, where many were possible. The fact that this group constitutes full half of all the introspective reports is a confirmation of the statement made at the beginning of this paper, that the significant conscious factors in controlled association belongs to the fore-period.

(2) *Marbs Intervening.*—Under this heading I have classed all those cases in which this interval was filled with various kinds of conscious events which aid in the finding of a correct response but can not be classed as images, sensations or feelings. Here the subject fitted his response into his fore-period formula or diagram, or he was aided by a vague memory of recent experience, or he reported that he simply "thought" of something which made the connection possible. On the other hand the interval was sometimes filled with a consciousness of the passing time, or a general confusion, or a feeling of certainty that the response was going to come easily or with difficulty, or that it would be right or wrong when it came. In some other instances sentences were formed in which the response word fitted. For example, the task was "give part of" and the stimulus word was "clock"; the subject formed a sentence like this: "What is part of a clock?" "A hand." These sentences were usually only half formed and the subject often contended that they were not in the form of words; that no words were present but the meaning was clear. Other reports revealed the presence of vague feelings of certainty, hesitancy, satisfaction, etc. One subject's introspection to the reaction to "year" "give the whole of," "month," was that in the main-period he had a kind of "tripping feeling" as though he was running up a series of months to get "year." When the task was to find whole or parts or subordinates the subjects often reported that they were aware of general parts and wholes, of big things and little things, things above and things below.

(2) *A Vacant Interval Intervening.*—Here the subject was aware of nothing but an interval of unfilled time. Sometimes, however, this gap was partly filled by a searching for a response word, or a feeling of effort or strain. When the response finally came

it was usually correct. Sometimes it came up gradually and sometimes it popped up suddenly. In a few instances the subjects reported that they were aware of the meaning of the response word before the word itself came.

(4) *Images Intervening.*—These images are mostly visual. At times they seemed to the subject to aid in getting the response, at other times they seemed to hinder or block the process, and again they appeared as neutral side lines. They ranged in vividness all the way from clear pictures to dim spatial notions. The following is a sample instance in which the image seemed to aid the process: Task, "give part of," stimulus "cart." Report: "Saw the side of the cart and picked out the front wheel." Here is another case: Task: "give part of," "house." Report: "Had an image of the side of a brick house and picked out one of the bricks." More frequent, however, were the instances in which the image hindered the process. One subject reported that in reacting to the stimulus "Give part of a house" he had a visual image of the house and was looking for a part of it. He could not find a name for any part that he saw, and finally responded "chimney" which he didn't see at all. In another case, when the subject was trying to find a part of a clock, he reported that he had an image of the wheels and a number of parts the name of which he knew well but could not say, so he finally said "hand" but he did not see the hand. More frequent than either of these were the reports in which the image seemed to be irrelevant, neither aiding nor hindering the process. Often the image was of the stimulus word or the object represented by it rather than of the response word or the object represented by it. Occasionally the image was of something which apparently had nothing to do with the process.

One subject reported a number of instances of imagery as checks on the response. After the response had been given an image would recur as a verification of the response. If the response word represented a concrete object, the image was of the response; but there were cases in which the image was of the situation in which the response was set. There were other cases in which the image was of the stimulus word or the object which it represented. These verifying images were usually visual and usually very distinct.

(5) *Conflicting Responses Intervening.*—When there was more than one right response possible to a given stimulus, several responses, any one of which would do, appeared in the margin of consciousness and struggled with each other for ascendency. Finally one gained headway over the others and was given. These competing responses never appeared in the form of words but remained

in the background in the form of dim meanings. They might be called potential words or the stuff from which words are developed. For example, when the task was "Give an example of" and the stimulus was "book," a subject reported that there was a rush of books toward the threshold of consciousness, for a time none of them came near enough to be named then finally one pushed its way through and was spoken.

(6) *Wrong Responses Inhibited, Intervening.*—The process here seems to be one of trial-and-error. The subjects reported that they merely allowed the stimulus to suggest responses in the "free-association" way and then kept rejecting the wrong ones until a right one appeared and was accepted. Sometimes one wrong response would come and sometimes several.

In addition to the cases classified under these six categories there is a number that do not admit of classification according to this scheme. Among them there are several interesting special cases. First of all there are instances in which the subject forgot the task words when the stimulus appeared and was utterly helpless until he went back to the fore-period and recalled the task. Sometimes he was unable even to recall it. A second form of special case is that of one subject who reported that certain movements like raising the chin, moving the hands, aided in getting a quick response.

The above classification only includes right responses. The instances of false reactions or wrong responses can be grouped under three heads. (1) Cases in which a false reaction was made and the subject thought he was right. (2) Cases in which he knew it was wrong before he spoke but the process was too far along to check it. (3) Cases in which he knew he was wrong the instant he spoke. All these taken together, however, constitute but a small fraction of the total number of reactions taken.

2. Conscious Events Intervening Between the Stimulus and the Response When the Task was Presented Indirectly

I found it convenient and proper to classify these reports under the same heading as those above by adding two minor divisions: (1) A few instances in which the process seemed blocked by the presence of irrelevant factors, and (2) Cases in which the subject lost the relation or set in the main-period and found it necessary to go back to the fore-period to re-set himself.

3. CONCLUSIONS FROM MAIN-PERIOD INTROSPECTIONS. KINDS OF INFLUENCE EXERTED BY PREPARATORY SET. INHIBITION AND FACILITATION

The conclusion drawn from these data is that preparatory set has two spheres of influence, inhibition and facilitation. In some reactions both kinds of influence were present, in other reactions one or the other kind was present alone, and in still others, neither was present.

(1) *Cases of Both Inhibition and Facilitation.*—All the instances in group (1) of the above classification can be considered as cases in which the preliminary set operated to inhibit all responses appearing in consciousness except one, and that the right one. Its inhibitive influence seems to be exerted before the stimulus appears. It not only inhibits wrong responses, but also a conflict of right responses. In addition to this inhibitive influence it exerts a facilitating influence, inasmuch as the right response seemed to the subjects to be pushed up immediately without any intervening processes, that is, without any extra aids. Thus we have a right to say that its influence is both inhibitive and facilitating. This sort of influence was exerted in 46 per cent. of the cases.

(2) *Cases of Inhibition Without Facilitation.*—Groups (2), (3) and (4) above represent this sort of influence. Here the set acts to inhibit wrong responses but fails to facilitate a right response and the subject has to resort to some extra means of getting it. Sometimes it is aided by marbs, sometimes by images, and sometimes by a feeling of effort. Sometimes the subject reported that he knew full well what he wanted but somehow he couldn't get it. He thus resorted to all sorts of means of getting it. He may go back to the fore-period and get re-set, or he may call up images or summon marbs. Thus we can say that the set serves to inhibit but fails to facilitate. There are about 38 per cent. of the reactions grouped here.

(3) *Cases of Facilitation without Inhibition.*—The percentage of such cases is small—only 5 per cent. of the total. This sort of influence refers to group (5) above in which it was noted that the set operates to call into consciousness or the margin of consciousness a number of conflicting responses. Here the set clearly does not inhibit else these conflicting responses would not appear.

(4) *Cases of Neither Inhibition nor Facilitation.*—In all these instances in which the subject had to consciously reject wrong responses suggested by the stimulus word, the set cannot be said to have either facilitated or inhibited. The influence here seems to be rather selective, since the subjects reported that they allowed all

these responses to appear and selected a right one from among them. The percentage of such cases is small, being 5 per cent.

Our conclusion is, then, that the principal influence of preparatory set is inhibitive. Inhibition with facilitation occurred in 46 per cent. of the cases, and without facilitation in 38 per cent. of the cases, making a total of 86 per cent. of the cases in which it occurred. On the other hand facilitation occured in 51 per cent. of the cases, but in only 5 per cent. without inhibition.

The story of the mechanism of controlled association is a story of how the processes of inhibition and facilitation operate. To make a statement about the inner workings of the neurones here involved would be to restate much that we have already said. In fact it would seem that facilitation and inhibition are simply *functions* of higher processes which work to promote the operation of bonds relative to the task or problem, and to prohibit the operation of irrelevant bonds. James[17] hints at this in the chapter on association:

"The truth must be admitted that thought works under conditions imposed ab extra. . . . It is true that a presiding arbiter seems to sit aloft in the mind, and emphasizes the better suggestions into permanence, while it ends by dropping out and leaving unrecorded the confusion." To say that we are conscious of inhibitions taking place means that we are conscious of the operation of the "*presiding arbiter*." This is probably what Royce[18] had in mind when he said: "We can therefore understand the psychology of live thinking processes only in the case we understand *when, how far, and under what conditions, inhibition becomes a conscious process*." But some of the results of the Külpe school and some of the results of this investigation tend to show that as thinking becomes more refined and automatic we tend to become more and more *unconscious* of our inhibition. Thus it would appear that just the opposite of Royce's statement is more true to the facts.

4. Relations Between Fore-period Reports and Main-period Reports. The Mechanism of Inhibition and Facilitation.

Having defined the nature of preliminary set in neurological terms as divergence and convergence, and having defined the influence of preliminary set as inhibition and facilitation, it remains now to see what relation, if any, exists between divergence and convergence on the one hand, and inhibition and facilitation on the other. To put it in a more concrete form, the problem is that of determining the most likely way of getting set when the task has one or both of these two kinds of influence. Is there any relation between getting set in any particular way and any one of the four types of influence which we have seen that the set exerts? The two tables, numbers I and II on the following pages attempt to answer this question. The columns represent the main-period classifications and the rows the fore-period classifications. The entries are the frequencies. The figures in the extreme right hand columns just under the totals are the median times of the fore-period and the main-period respectively, given in seconds. The probable error of these figures is not given in the table but is about .08 sec.

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[17] James, "Psychology," 1, p. 552.

[18] Royce, "Recent Logical Inquiries and their Psychological Bearings," *Psychol. Rev.*, 1902, 9, 131, 132ff.

TABLE I

THE DIRECT PRESENTATION OF THE TASK

F.P. M.P.	(1) By Marbs	(2) By Immediate Adjustment	(3) By Specific Motor Sets	(4) By Spatial Schemata or Diagrams	(5) By Key Words or Syllables	(6) Unclassified	Total	Med. M.P. Time
(1) Nothing Intervening	44	41	9	3	9	11	117	
							1.2	−1.0
(2) Marbs Intervening	42	12	4	0	0	5	63	
							1.3	−1.1
(3) Vacant Interval Intervening	19	2	8	2	3	8	33	
							1.2	−1.5
(4) Images Intervening	27	16	15	3	8	6	75	
							1.3	−1.3
(5) Conflicting Responses Inter.	0	2	0	0	6	0	8	
							1.2	−1.2
(6) Wrong Responses Inhibited, Inter.	15	3	0	1	3	0	22	
							1.1	−1.6
(7) Unclassified	4	12	11	12	2	10	51	
							1.0	−1.4
Totals	142	88	47	21	31	40	369	
Med. F.P.	1.0	.9	1.4	1.3	1.4	1.3	1.20	
Med. M.P.	1.1	1.0	1.1	1.2	1.1	1.4	1.15	
Wrong or false reactions	21	5	2	3	0	0	31	

Grand Total 400 reports

A careful study of these tables will reveal some facts about certain relationships that exist between certain classes of main-period introspections and certain classes of fore-period introspections. If A represents all the cases in which the subjects reported that they were aided in getting set by the use of marbs in the fore-period, and if B represents all cases in the main-period in which nothing intervened between the stimulus and the response, —*i. e.*, if A is all the cases in group (1) of the fore-period reports (Table I.), and B is all the cases of group (1) of the main-period reports, then (AB) will represent all the A's that are B's and all the B's hat are A's. Then, according to a well-known statistical formula,[19]

TABLE II

The Indirect Presentation of the Task

F.P. M.P.	(1) Consciousness of an Undifferentiated Relation	(2) Consciousness of a Differentiated Relation	(3) Consciousness of a Named Relation	(4) Consciousness of a Spatial Relation	(5) Motor Sets	(6) Images	(7) Repetition of Task Words	(8) Unclassified	Total	Med. M.P. Time
(1) Nothing Intervening....	39	37	38	18	30	11	8	7	188	1.4 – .9
(2) Marbs Intervening.....	0	19	11	10	8	4	4	5	61	1.4–1.1
(3) Vacant Inter. Intervening	0	6	6	8	4	1	1	1	27	1.4–1.2
(4) Images Intervening.....	2	7	4	4	4	17	0	4	42	1.3–1.2
(5) Conflicting Responses...	3	8	0	0	1	0	1	1	14	1.1 –1.5
(6) Wrong Responses inhibited...............	0	2	2	0	3	0	11	1	19	1.2–1.8
(7) Went Back for Re-set...	0	2	2	0	3	0	0	1	8	1.3 –2.0
(8) Process Blocked	2	0	4	0	0	0	0	0	6	1.3 –2.0
(9) Unclassified............	2	3	2	2	0	0	0	4	13	
Total.................	48	88	68	44	54	33	25	23	383	
Med. F.P..............	1.0	1.2	1.1	1.5	1.4	1.5	1.1	1.2	1.25	
Med. M.P...........	1.0	1.1	1.0	1.1	1.0	1.1	1.1	1.4	1.10	
Wrong or False Reactions.	1	0	0	5	2	0	0	7	17	

Grand Total 400 reports

if (AB) is equal to ((A)(B))/N there is no relationship,
if (AB) is greater than ((A)(B))/N the relationship is positive.
if (AB) is less than ((A)(B))/N the relationship is negative.

n this case (AB) = 44 and

$$\frac{(A)(B)}{N} = \frac{(117)(142)}{369} = 45 +.$$

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[19] G. Undy Yule, "Theory of Statistics," 1916, p. 28.

Now 44 is less than 45 and the relationship is negative. But how much negative? Mr. Yule[20] has given a formula for determining this. The formula is so worked out that plus 1 means complete positive association between the two attributes, zero means no association at all, and minus 1 means complete "disassociation." The formula is

$$Q = \frac{(AB)(ab) - (Ab)(aB)}{(AB)(ab) + (Ab)(aB)}.$$

It takes into account the non-A's as well as the A's and the non-B's as well as the B's. It is customary to designate the non-A's by *a* and the non-B's by *b*. In the present example then, *a* would be 369 − 142 = 227 and *b* would be 369 − 117 = 252. But how are we to find the other values? It is clear that (Ab) = all the A's that are not (AB)'s, so (Ab) = 142 − 44 = 98. Similarly (aB) = all the B's that are not (AB)'s, so (aB) = 117 − 44 = 73. Now (ab) = all the a's that are not (aB)'s, so (ab) = 227 − 73 = 154. Then by substitution in the formula, Q = − .02. This is so near zero that we can say there is no association between getting set by marbs and nothing intervening in the main-period.

But by the same formula and the same technic there is an association of + .30 between getting set by *immediate adjustment* in the fore-period and *nothing intervening* in the main-period, that is, between group (2) fore-period and group (1) main-period. It will be remembered that *immediate adjustment* is simply the name which I have applied to the absence of conscious events in the fore-period and *nothing intervening* the name for the absence of conscious events in the main-period. But the positive association of .30 between the absence of conscious events in these two respective periods does not imply that if the fore-period is vacant the main-period will also be vacant until we have tested the amount of association between all the other ways of getting set and the *nothing intervening* main-period. We have just seen that the association between getting set *by marbs* and this particular main-period group is − .02, and it is quite obvious from the table that the association will be still lower if we make the calculations for the other three ways of getting set. Thus we can say that if the subject gets set in the fore-period by *immediate adjustment* the *most likely* resulting main-period will be that of the *nothing intervening* type.

I have worked out each section of these two tables by this formula and have derived the coefficients of association between each fore-period group or class and each main-period class. Below I shall list only the cases of the highest positive associations:

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[20] *Ibid.*, p. 38.

TABLE III

Results from Table I

The Direct Presentation of the Task

Fore-period Class No.	Main-period Class No.	Q
(2)	(1)	.30
(1)	(2)	.65
(3)	(3)	.38*
(3)	(4)	.34
(4)	(7)	.81
(5)	(5)	.90*
(1)	(6)	.34

TABLE IV

Results from Table II

The Indirect Presentation of the Task

Fore-period Class No.	Main-period Class No.	Q
(1)	(1)	.69
(2)	(5)	.64
(4)	(3)	.57
(3)	(8)	.81*
(5)	(7)	.58*
(6)	(4)	.86
(7)	(6)	.87

I have not attempted to compute the probable error of these coefficients, but have starred those which appear from the original data to be most unreliable. The formula itself has certain disadvantages, one of which is that $Q = 1$ when $(AB) = A$ or when $(AB) = B$. Mr. Yule gives another formula in which this difficulty is overcome.[21] This formula is $r = N.d./\sqrt{(A)(a)(B)(b)}$ in which $d = (AB) - (A)(B)/N$. Here $r = 1$ only when $(AB) = (A) = (B)$. But it has the disadvantage that the proportion of A's to the non-A's affects the magnitude of r which is not true of the formula which I have employed. "The value is independent of the relative proportions of A's and *a*'s included in the table. This property is of importance, and renders such a measure of association specially adapted to cases (*e. g.*, experiments) in which the proportions are arbitrary."[22]

Some psychological conclusions are to be drawn from these tables with regard to the various ways of getting set and the kind of influence that the task exerts. (1) The preparatory set is most likely to have both a facilitating and inhibiting influence when the subject gets set by *immediate adjustment* (when the task is presented directly) and by *consciousness of an undifferentiated relation* (when the task is presented indirectly). (2) When the set is by marbs or by motor sets (direct) and by a consciousness of spatial relations and by *images* (indirect) the influence is *most likely*[23] to be inhibition without facilitation. (3) The influence is *most likely* to be facilitation with inhibition when the set is by key words or syllables (direct) or by a consciousness of a differentiated but unnamed relation (indirect). (4) The influence is *most likely* to be neither inhibitive nor facilitating but rather selective when the set is by marbs (direct) and by repetition of task words, motor sets and named relations (indirect).

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* Most unreliable cases.

[21] *Op. cit.*, p. 217.

[22] *Ibid.*, p. 38.

These conclusions can be shown best in a table.

TABLE V

F.P. Direct.	F.P. Indirect	M.P.	*Q* Direct	*Q* Indirect.
(2)	(1)	(1) F. & I.	.30	.69
(1)	(4)	(2) I.	.65	.28
(3)	(4)	(3) I.	.38	.57
(3)	(6)	(4) I.	.34	.86
(5)	(2)	(5) F.	.90	.64
(1)	(7)	(6) S.	.34	.87
	(5)	(7) S.	.58	
	(3)	(8) S.	.81	

F. & I. = both facilitation and inhibition
I. = inhibition without facilitation
F. = facilitation without inhibition.
S. = neither facilitation nor inhibition.

It will be remembered that in the analysis of the nature of preparatory set, two processes were observed, task-notions and task-sets, and that these two processes have as their physiological bases the principles of divergence and convergence respectively. The introspective reports of the fore-period show that sometimes one and sometimes the other of these two processes were emphasized. From the above tables and from the analysis of the relationships between the fore-period and main-period introspections, there is some evidence for believing that divergence favors facilitation and convergence favors inhibition. That is, when the task-notion process is emphasized, the influence of the set seems to be in the direction of facilitation; while on the other hand, when the task-set process is emphasized, the tendency is in the direction of inhibition. The evidence for this is by no means conclusive,—I simply mention it as an interesting hypothesis.

This chapter would not be complete without calling attention to the false reactions. While they are so few in number that they scarcely deserve to be mentioned, yet they offer some interesting features. When the subject gives a wrong response the most likely way of getting set is by marbs. The coefficient of association here is .34. It will be recalled from a previous statement that the coefficient of association between marbs and the various main-period processes is the highest (in the right responses) with those cases in which wrong responses occurred but were inhibited. But this fact becomes less astonishing when we recall that a major part of the marbs reported in the fore-period were those of uncertainty, doubt, unfamiliarity, etc. If we could isolate these marbs of uncertainty from those of a more positive nature, we would probably find that the association between them and false reactions, or tendencies to false reactions, would be very much higher.

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[23] It should be noted that "most likely" need not mean "very likely."

CHAPTER VII

EXPERIMENTAL RESULTS

Time Measurements

THIS chapter will deal with the second variety of data afforded by the investigation, namely,—time measurements of both the fore-periods and main-periods. The problem will be to determine the amount of influence that preparatory set exerts on the associative reaction. My general hypothesis is that when the preparatory set is at a maximum, the time of the association is at a minimum, other things being equal; and conversely when the preparatory set is at a minimum, the time of the association will be at a maximum, other things being equal. A further assumption is that the difference between this maximum and minimum association time is a measure of the amount of influence of preparatory set. Another way of stating these assumptions is that the amount of influence of the set on the reaction (in the main-period) is proportional to the degree of completeness of the set (in the fore-period). The problem then narrows itself down to that of obtaining a measure of the relation between the length of the fore-period and the length of the main-period.

I. PREPARATORY SET AT ITS MAXIMUM; ASSOCIATION TIME AT ITS MINIMUM

The first thing to do is to create experimental conditions under which the preparatory set is at a maximum. Such conditions are afforded by the first experiment in which the subject was allowed all the time he wanted to get set Here the experimenter exposed the task and the subject was instructed to look at it until he was ready for the stimulus, then press his key which would cause the task to disappear and the stimulus word to appear. In this experiment the fore-period varied in length from about .4 sec. up to 1.5 sec.; and the main-period varied from about, .5 sec. to 2.5 sec. If we assume that the relatively short fore-periods represent cases in which the subject was inadequately prepared, we would expect such cases to be followed by relatively long main-periods and a negative correlation would result. But if this assumption is true, then this experiment does not fulfil the conditions under which the preparatory set is always at its maximum. If, on the other hand, we assume that the subjects were always adequately and completely set, even in the shortest fore-periods, then the experiment does fulfil the conditions and main-periods represent the minimum association times.

There is a variety of ways of testing these hypotheses. I have chosen the correlation method. While I regard coefficients of correlation as often misleading and dangerous, yet I believe that they are adequate to test these assumptions. The first attempt was to take the fore-periods of each reaction for each subject, combining all tasks, and correlate them with their corresponding main-periods. The correlations were made by the Pearson formula

$$r = \frac{\Sigma xy}{n\sigma_x\sigma_y}$$

and the results for 15 subjects were as follows:

TABLE VI

Subject	Direct 25 reactions	Indirect 25 reactions.
(1)	−.03	.50
(2)	.56	.17
(3)	.07	.29
(4)	.19	.12
(5)	.04	.25
(6)	.38	−.04
(7)	.34	.42
(8)	−.35	.14
(9)	−.08	.51
(10)	.48	.40
(11)	.32	.08
(12)	.08	.29
(13)	.07	.36
(14)	.21	.30
(15)	.06	.21
	Av. .162	.262

These correlations seem to indicate that the first assumption is false, and that short fore-periods are not followed by long main-periods. This is certainly the case since there are but four negative correlations out of the entire thirty. But we must not be too hasty in concluding that it verifies the second hypothesis that all fore-periods represent adequate preparation and thus do not affect the length of the main-periods, until we have considered the other factors present which operate to throw the correlations toward zero. The question is: What are the factors causing variation in the fore-period, and what factors cause variation in the main-period? Is there a common factor?

The factors which operate to make the fore-period long or short are very inconstant and vary (*a*) with the task and (*b*) with the practice which comes from the repetition of the same task. It will be remembered that there were used in this experiment five tasks which appeared at random ten times each. The difficulty of getting set for one task was not the same as that for another. For example, when the task was "give opposite of" it took the subjects much less time to get fully set than it did when the task was "give subordinate of." The time for complete and adequate set, therefore, varied with the difficulty of the task. In the second place it varied within each task with the number of times that it appeared. For example, it took less time for complete preparation the fifth time the task appeared than it did the first time. Thus for each task there was a decided practice effect.

The three factors which we have already recognized as determining the length of the main-period are (1) The influence of preparatory set (2) the reproductive tendencies and (3) the inhibition between the number of possible responses. Of these three, only the first can be related to the fore-period. Any measure of general correlation whatever can indicate only the amount of the influence of the task on the whole main-period. But before such a measure can be computed it is first of all necessary to eliminate some of the irrelevant factors in both periods.

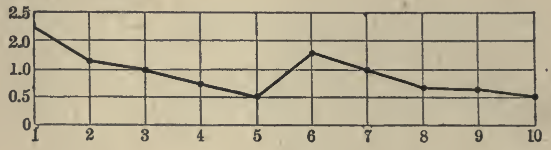
Variations in the fore-period due to differences in the hardness of the different tasks can be eliminated by combining all the reactions for any one task and correlating by tasks. According to this method the following correlations result:

TABLE VII

Task	*r* Direct.	
Opposites	.266	
Whole-parts	.005	
Part-wholes	.098	
Subordinates	.115	
Verb-objects	.150	
Av.	.127	P.E... .07

These correlations are about the same as those resulting when we correlated by subjects. The difficulty here is that we have introduced another variable, namely, individual differences. We have also yet to eliminate the practice effect in the fore-period. If after we have eliminated these irrelevant factors, we still get a low correlation, then we shall be justified in assuming that there is no relationship existing between the two periods and that factors causing variability in the fore-period do not cause corresponding variability in the main-period.

I have attempted to eliminate the practice effect in the fore-period by plotting a practice curve for each subject and for each task. It will be remembered that each task appeared ten times in the entire experiment, five times in the first series and five in the second. But there was an interval of two months between the first and second series. By the end of the first series, when each task had appeared five times, I found that almost every subject had reached his maximum practice. But at the beginning of the second series the task curve went up for the first two or three appearances but went down again, so I took as a measure of the fore-period the average of the fourth, fifth, eighth, ninth, and tenth, appearances. This seemed to give a "*reduced set-time*" for each task. The following is a sample curve showing the length of the fore-periods for each appearance of a task.



For the measure of the main-period I used the median of the ten reactions to each task. The median was used since it is least affected by the very long or very short reactions. This procedure gives a series of five measures for each individual, one measure or set of measures for each task. The fore-period measure is the "reduced set-time"; and the main-period measure is the median time required to react to ten stimulus words according to one task.

Treating the raw data in the way just described we get Table VIII. The rows in this table represent individual scores and the columns represent fore-periods and main-periods as indicated. At the foot of each column is given the average of it and its M.D. (σ). These averages are summed up and listed according to tasks in the summary table at the end. Table IX. is derived from Table VIII. by dividing the deviation of each measure in a column from the average of that column by the mean square deviation of that column. Any entry in any column in Table IX. is simply the deviation from the average of the column of the corresponding entry in Table VIII. expressed as a percentage of the mean square deviation of that column. The advantage of constructing Table IX. will be given later.

It will be observed that correlations can be obtained at once from Table IX. The well-known Pearson's formula is

$$r = \frac{\Sigma xy}{n\sigma_x\sigma_y}$$

in which Σxy is the sum of the cross-products of the pairs of deviations from their respective central tendencies. The formula can be expressed

$$r = \frac{\Sigma\left(\frac{x}{\sigma x}\cdot\frac{y}{\sigma y}\right)}{n}.$$

TABLE VIII

The Entries are in Seconds

	Opposites				*Whole-parts*			
	F.P. Dir.	F.P. Indir.	M.P. Dir.	M.P. Indir.	F.P. Dir.	F.P. Indir.	M.P. Dir.	M.P. Indir.
(1)	.75	.95	.80	1.05	.65	1.05	1.00	1.00
(2)	.95	.87	.90	.80	.90	1.30	1.07	1.00
(3)	.90	1.10	1.00	1.05	1.15	1.95	1.27	1.15
(4)	.87	1.00	1.00	1.05	.95	1.25	1.25	1.30
(5)	.95	.90	.90	.97	1.15	1.35	1.27	1.25
(6)	.85	1.02	.90	.90	.90	1.20	1.00	1.05
(7)	.90	.90	.85	.80	.85	1.70	1.25	1.20
(8)	.65	.72	.85	.80	.70	.95	1.30	1.25
(9)	.75	1.00	1.05	1.00	.95	1.57	1.30	1.35
(10)	.87	1.00	.80	.90	.95	1.12	.90	1.15
(11)	.82	.85	1.00	.87	.95	1.10	1.30	1.35
(12)	.70	.82	.85	.80	.80	.92	1.15	1.35
(13)	.70	.75	.85	.80	.65	.85	1.00	1.25
(14)	.95	1.00	.95	.85	1.10	1.25	1.00	1.15
(15)	.60	.72	.80	.85	.60	.77	1.02	1.20
Av.	.81	.91	.90	.90	.88	1.22	1.14	1.20
σ	.12	.10	.08	.09	.16	.31	.15	.11

	Part-wholes				*Subordinates*			
	F.P. Dir.	F.P. Indir.	M.P. Dir.	M.P. Indir.	F.P. Dir.	F.P. Indir.	M.P. Dir.	M.P. Indir.
(1)	.60	.75	.95	.95	.70	1.00	1.15	1.25
(2)	.90	1.55	1.00	.85	1.15	1.12	1.35	1.00
(3)	1.20	1.52	1.10	1.20	1.15	1.75	1.90	1.80
(4)	1.00	1.35	1.15	1.50	.95	.92	1.40	1.75
(5)	1.20	1.75	1.05	1.10	1.20	1.05	1.25	1.30
(6)	.85	1.22	1.05	1.00	.95	1.15	1.25	1.40
(7)	.85	1.52	1.00	1.15	1.00	1.40	1.50	1.50
(8)	.60	.75	1.10	.95	.70	.75	1.30	1.50
(9)	1.00	1.55	1.27	1.20	.82	1.35	1.30	1.70
(10)	.80	1.15	.80	1.00	.95	.95	1.10	1.35
(11)	.85	1.00	1.35	1.20	.95	1.00	1.40	1.40
(12)	.75	1.15	1.15	1.00	.77	1.00	1.00	1.40
(13)	.87	.80	.95	1.00	.75	.90	1.15	1.50
(14)	1.12	1.12	1.05	1.24	1.10	1.20	1.35	1.25
(15)	.60	.80	1.00	.95	.62	.80	1.10	1.10
Av.	.88	1.20	1.06	1.08	.91	1.09	1.30	1.41
σ	.19	.33	.13	.17	.18	.25	.21	.22

Verb-objects

	F.P. Dir.	F.P. Indir.	M.P. Dir.	M.P. Indir.
(1)	.67	.85	.95	.90
(2)	.85	.85	.95	.87
(3)	1.30	1.15	1.05	.95
(4)	1.00	1.10	1.17	1.15
(5)	1.25	1.05	1.10	1.00
(6)	1.05	.95	.90	.80
(7)	.85	1.00	1.00	.90
(8)	.80	.75	.90	.80
(9)	1.02	1.15	1.05	1.10
(10)	.90	1.00	.90	.90
(11)	.85	.90	1.10	1.10
(12)	.75	.85	.90	.80
(13)	.85	.75	.85	.80
(14)	1.05	1.10	1.05	.85
(15)	.60	.80	.90	.80
Av.	.92	.95	.98	.91
σ	.18	.13	.10	.12

Averages of Subjects

	M.P. Dir.	M.P. Indir.
(1)	.97	1.03
(2)	1.06	.89
(3)	1.27	1.23
(4)	1.19	1.36
(5)	1.12	1.12
(6)	1.02	1.30
(7)	1.12	1.11
(8)	1.09	1.06
(9)	1.19	1.27
(10)	.90	1.06
(11)	1.19	1.85
(12)	1.01	1.07
(13)	1.96	1.08
(14)	1.08	1.07
(15)	.97	.98
Av.	1.08	1.10

Summary of Averages

	F.P. Dir.	F.P. Indir.	M.P. Dir.	M.P. Indir.
Opposites	.81	.91	.90	.90
Whole-parts	.88	1.22	1.14	1.20
Part-wholes	.88	1.20	1.06	1.08
Subordinates	.91	1.09	1.30	1.41
Verb-objects	.92	.95	.98	.91
Av.	.88	1.11	1.08	1.10
σ	.17	.21	.13	.14

If we let $a = x/\sigma_x$ and $b = y/\sigma_y$ then $r = \Sigma ab/n$. Now any column in Table IX. can be regarded as a and any other column as b since these columns were derived by dividing each deviation from the average of the corresponding column in Table VIII. by the mean square deviation of that column. Thus the coefficient of correlation between any two columns in Table IX. can be obtained by dividing the sum of the cross products of their entries by the number of entries in the columns, which in this case is 15. I shall not attempt to go into a defence of this method nor to recite all of its advantages over the straightforward Pearson's method. For such a statement the reader is referred to an article by Woodworth in which he sets forth the method in detail.[1] The correlations derived by this method are given in Table X.

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[1] R. S. Woodworth, "A Study of Statistical Method," *Psych. Rev.*, 1912, 19, pp. 99–120.

TABLE IX

Entries are d/σ of Table No. VIII

	Opposites				*Whole-parts*			
	F.P. Dir.	F.P. Indir.	M.P. Dir.	M.P. Indir.	F.P. Dir.	F.P. Indir.	M.P. Dir.	M.P. Indir.
(1)	−58	+38	−125	−155	−138	−43	−91	−175
(2)	+121	−33	000	−103	+12	+24	−42	−175
(3)	+76	+178	+125	+155	+162	+231	+87	−44
(4)	+54	+84	+125	+155	+42	+08	+71	+87
(5)	+121	−09	000	+77	+162	+40	+87	+44
(6)	+31	+108	000	000	+12	−08	−91	−131
(7)	+76	−09	−63	−103	−18	+151	+71	000
(8)	−147	−174	−63	−103	−108	−82	+103	+44
(9)	−58	+84	+189	+103	+42	+110	+103	+131
(10)	+54	+61	+125	000	+42	−32	−155	−44
(11)	+09	−56	+125	−26	+42	−40	+103	+131
(12)	−103	−80	−63	−103	−43	−95	+06	+131
(13)	−103	−66	−63	−103	−138	−119	−91	+44
(14)	+121	+84	+63	−51	+102	−24	−91	−44
(15)	−192	−121	−125	−52	−168	−151	−74	00
	Part-wholes				*Subordinates*			
(1)	−145	−135	−88	−75	−120	−36	−72	−75
(2)	+10	+105	−50	−131	+131	+14	+24	−189
(3)	+166	+98	+27	+69	+131	+266	+228	+175
(4)	+62	+45	+65	+240	+19	−66	+48	+164
(5)	+166	+166	−11	+11	+159	−16	−24	−52
(6)	−16	+07	−11	−46	−08	+24	−24	−06
(7)	−16	+98	−50	+40	+42	+125	+96	+39
(8)	−145	−166	+27	−74	−120	−137	000	+39
(9)	+62	+105	+161	+69	−50	+105	000	+130
(10)	−39	−11	−204	−46	+19	−56	−96	−29
(11)	−16	−60	+220	+69	+19	−36	+48	−06
(12)	−67	−15	+65	−46	−77	−36	+145	−06
(13)	−02	−120	−88	−46	−92	−76	−71	+39
(14)	+127	−23	−11	+97	+103	+44	+24	−75
(15)	−145	−120	−50	−74	−161	−117	−96	−143
	Verb-objects				*Average Standing*			
(1)	−131	−74	−34	−12	−118	−46	−82	−98
(2)	−37	−74	−34	−92	+47	+31	−20	−139
(3)	+201	+147	+64	+29	+147	+182	+118	+75
(4)	+43	+110	+185	+197	+40	+36	+99	+168
(5)	+176	+74	+121	+71	+157	+51	+34	+31
(6)	+69	000	−83	−96	+17	+26	−22	−70
(7)	−37	+37	+14	−12	+09	+80	+14	−21
(8)	−64	−147	−83	−96	−117	−141	−3	−38
(9)	+56	+147	+63	+155	+10	+112	+103	+117
(10)	−11	+37	−83	−12	+13	+1	−133	−33
(11)	−37	−37	+112	+155	+3	−46	+122	+64
(12)	−90	−74	−83	−96	−76	−60	−44	−22
(13)	−37	−144	−132	−92	−74	−105	−89	−31
(14)	+69	+110	+63	−54	+104	+34	−5	−25
(15)	−170	−110	−83	−92	−167	−124	−88	−90

TABLE X

	Direct		Indirect	
Task	r	P.E.	r	P.E.
Opposites	.374	,22	.531	.18
Whole-parts	.304	.23	−.079	.09
Part-wholes	.208	.25	.326	.21
Subordinates	.568	.19	.414	.19
Verb-objects	.431	.20	.711	.11

These correlations all being positive (except one) tell us that on the whole an individual whose fore-period is relatively long has a relatively long main-period and vice versa. But before we can decide just to what extent, if any, the main-period depends on the length of the fore-period we must have more detailed information than that given in the bare coefficients of correlation. We need to know something about the relative standing of each individual in both periods. Table IX. furnishes us with this information. A single glance at the table will enable us to locate the factors that make the correlation high or low, positive or negative. If all individuals who stand high in the fore-period stand correspondingly high in the main-period, and if all those who are low in the fore-period are low in the main-period, the resulting correlation would tend to be positive and high. If, on the other hand, individuals standing high in the fore-period, stand low in the main-period and vice versa, the correlation would be negative. But if the standing of an individual in the fore-period helps one to predict nothing as to his standing in the main-period, the correlation would tend towards zero.

The truth of these statements becomes clearer if we state the main features of this method of correlation. The first essential is that the average means the same thing in respect to all distributions. It is regarded as zero. Second, the measure of variability of each distribution (here the mean square deviation) means the same thing. It is taken as unity. Thus all the entries in Table IX. mean the same thing. They are deviations from the average expressed as percentages of the mean square deviations of each column.

Looking at Table IX. again with these facts in mind we see that there is little individual consistency and that an individual's standing in the fore-period tells us practically nothing of his standing in the main-period. This being the case, we conclude that there is no *significant* correlation between the *data* representing the fore-period and those representing the main-period. But this does not mean that the length of the main-period is independent of the length of the fore-period. It simply means if there is a dependence, it cannot be measured from these data since, as we shall presently see, the fore-period is seldom short enough to affect the main-period.

The fact that we find low correlation here verifies our second hypothesis that in almost every case the subject is adequately prepared in the fore-period so that variations in this period do not produce corresponding variations in the main-period. The shortest fore-period times might be considered as representing the minimum time for adequate preparation, and the longer ones are due to unfamiliarity with the task, the subject's cautiousness, and possible other unknown factors. We have no evidence whatever that the shortest fore-periods represent incomplete set, but we do have evidence that in every case the subject was completely prepared and most of the time took more time than was necessary for this preparation. The following table gives some fore-period data which bear out these conclusions.

TABLE XI

Task	Range	Av.	M.D.	"Reduced time."
Opposites	.5 to 2.2	1.00	.32	.81
Whole-parts	.4 to 2.0	1.04	.47	.88
Part-wholes	.4 to 2.2	1.04	.36	.88
Subordinates	.5 to 2.4	1.12	.36	.91
Verb-objects	.5 to 1.5	1.03	.27	.92
				Av. .88

This table shows that the range is from about .4 sec. to 2.5 sec., and that the average "reduced set-time" is .88 sec. The conclusion to be drawn is that even .88 sec. is more time than is necessary for complete set after practice. If we are justified in concluding that in almost every case the subject was completely and adequately set, but in most instances took more time than was necessary, then the main-period times represent the time it took to respond when the set was exerting its maximum influence, and by hypothesis the minimum. Thus we have fulfilled the conditions under which the influence of the set is maximum, and the association time the minimum. But since in most cases the subjects took more time than was necessary to get set, it remains to find the minimum time for the maximum set. In a later experiment I found that this time is about .5 second which is the lower limit of the range of the fore-periods shown in Table XI.

Up to this point I have kept separate the two series of data, namely, those derived from the direct presentation of the task and those derived from the indirect presentation of it. I have done this to determine whether or not the method of presenting the task had any effect on the length of the main-period. It will be remembered that the stimulus words and the subjects used in both the direct and indirect experiments were the same, but the experiment was so arranged that the practice effect in the second presentation of the same stimulus words favored neither the direct nor the indirect. Tables VIII. and IX. compare the two forms of presentation. The summary at the end of the Table VIII. is the most interesting. It shows in the first place that there is a noticeable difference in the fore-periods. The direct is about .23 shorter than the indirect. In the second place it shows no difference at all in the main-periods. The general conclusion to be derived from this table is that on the whole it takes longer to get set when the task is presented indirectly, but once the set is obtained the reaction is accomplished in about the same time as when the task is presented directly.

But a comparison of the averages and the variabilities does not tell the whole story. One subject might react quickly in one case and slowly in the other and the process might be reversed in another subject. So it is necessary to measure the individual consistency. Table IX. shows the relative standings of each subject in each task and in each of the two methods of presentation. By averaging the products of the columns marked M.P. Dir. and M.P. Indir. we get the following correlations.[2]

TABLE XII

Task	M.P. Dir. and M.P. Indir.	P.E.
Opposites..............	.431	.21
Whole-parts............	.563	.19
Part-wholes............	.444	.22
Subordinates...........	.535	.21
Verb-objects...........	.791	.10
Av..................	.554	.19

These correlations are much lower than one would have expected and indicate a difference somewhere. This difference can be found by examining the table. Since the average of each distribution is about the same, being 1.10 and 1.08 and since the σ of each distribution is about the same, being .13 and .14 for purposes of comparison the entries in Table IX. can be considered as absolute quantities. The columns under "average standing" in the lower right-hand corner of Table IX. show that there is high degree of individual inconsistency. For example subject (2) stands 118 per cent. of the σ of the distribution higher in the indirect than in the direct; while on the other hand subject (10) stands 100 per cent. higher in the direct than in the indirect.

The conclusion here is that accepting the direct as the standard, then the indirect presentation of the task lengthens the main-period in some cases and shortens it in other cases, but on the whole, or taking all cases together, does not affect it. From this point on we shall drop the distinction between direct and indirect. In all the following experiments the task is presented directly and all comparisons with experiment I. will mean a comparison with the results from the direct presentation.

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[2] By the method outlined above.

II. PREPARATORY SET AT ITS MINIMUM: ASSOCIATION TIME AT ITS MAXIMUM

Having determined the length of the main-period when the preparatory set is complete, the next problem is that of creating experimental conditions under which the set is reduced to its minimum, and keeping these conditions as similar as possible to those of the first experiment, find the length of the main-period.[3]

By reducing the fore-period to its minimum, that is by making it as short as possible and still have a fore-period, the task words will remain on the screen long enough for the subject to read them and know what is wanted but presumably not long enough for him to get set. This gives approximately the same conditions as experiment I. with the time of the fore-period greatly reduced.

By means of a pendulum arrangement (described in the chapter on apparatus) I limited the fore-period to .15 sec. The experimental results are given in the following tables and in curve I. I shall refer to this experiment as exp. II.

The entries in Table XIII. are the medians and the probable errors of all subjects' reactions in each experiment. In experiment I. there were 50 reactions per individual, ten per task; in experiment II. there were 90 reactions per individual, 15 per task. The entries in Table XIV. are the medians of the distributions in which all subjects were combined. There were thus, 150 measures in each distribution by tasks in experiment I. and 225 in experiment II. The averages given at the foot of each column of Table XIV. are the averages of the medians for each task; and the averages at the foot of the columns in Table XIII. are the averages of the medians for each individual. The purpose of giving these data in these two ways is to ascertain whether the differences in time is due to variation in subjects or in tasks or in both.

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[3] One's first guess would be that the free-association experiment would fulfil these conditions. It is a general observation of psychologists that free-associations take longer than controlled. The reason assigned to this is that in the case of the latter the preparatory set limits the range of response and facilitates it. In order to test this matter I took several hundred free-association reactions and found the median reaction time was about 1.046 seconds against the median time of 1.102 seconds of the controlled reactions taken under similar conditions. The reason for this result might be that in the case of the controlled reactions the task changed from reaction to reaction; whereas in the case of the free-associations the instructions "react with the first word suggested" remained constant throughout. But the main reason why the free-association experiment will not fulfil these conditions is because it is never strictly free. Watt declined to use it on this account, and Messer found by a special experiment that the subject usually imposes on himself some sort of a task and thus reacts under the influence of a more or less specific set.

TABLE XIII

Summary of Exp. I and Exp. II. All Tasks Combined

	Median M.P. Exp. I	Median M.P. Exp. II	P.E. Exp. I	P.E. Exp. II
(1)	.97	1.20	.10	.12
(2)	1.05	1.46	.14	.13
(3)	1.26	1.73	.11	.17
(4)	1.19	1.48	.12	.09
(5)	1.12	1.06	.05	.11
(6)	1.02	1.27	.12	.13
(7)	1.12	1.39	.15	.15
(8)	1.09	1.21	.11	.13
(9)	1.19	1.37	.15	.14
(10)	.90	1.20	.12	.11
(11)	1.12	1.37	.14	.14
(12)	1.01	1.28	.11	.09
(13)	.96	1.19	.12	.14
(14)	1.08	1.43	.10	.16
(15)	.96	1.19	.08	.10
Av.	1.070	1.322	.11	.12

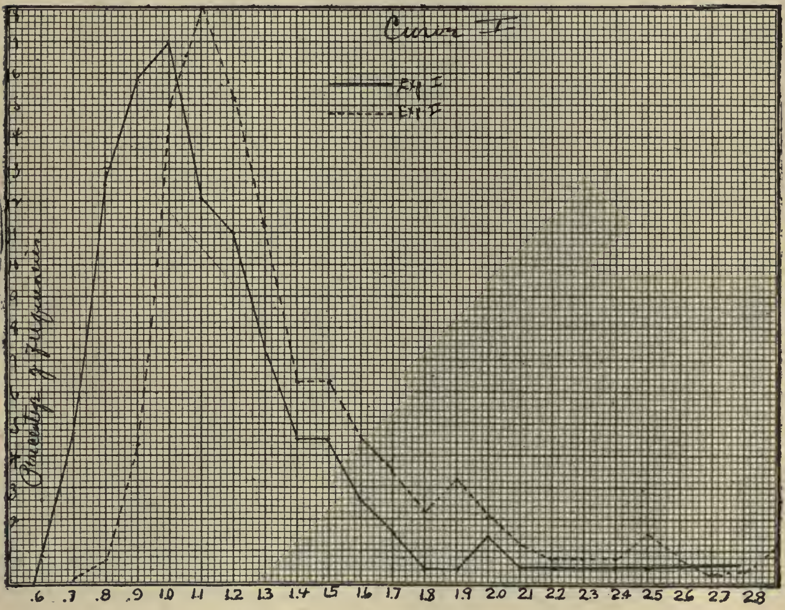
The most significant thing about these tables is that they show a difference between the lengths of the main periods in the two experiments. There are three things to be considered concerning this difference. (1) What is the difference? (2) How reliable is it? (3) How is it to be interpreted?

TABLE XIV

Summary of Exp. I and Exp. II by Tasks. All Individuals Combined

	Exp. I		*Exp. II.*		
	M.P.	P.E.	M.P.	P.E.	D.
Opposites	.95	.09	1.15	.11	.20
Whole-parts	1.15	.18	1.26	.20	.11
Part-wholes	1.09	.14	1.31	.25	.22
Subordinates	1.36	.25	1.59	.26	.23
Verb-objects	1.04	.16	1.19	.17	.15
Surpa-ordin.			1.37	.20	
Averages	1.118	.16	1.311	.20	.182

Table XIII. shows that in every subject except one the median main-period of experiment I. is shorter than that of experiment II. The difference of the averages of the medians as shown by this table is .253 second. Table XIV. shows a smaller difference. The difference of the averages of the median by tasks as given here is .193 second. Still a third, and perhaps more reliable difference, can be obtained by combining all tasks and individuals in each experiment into a total distribution table. The difference between the medians of two such distributions is .280 second. Thus we have at least three measures of the difference. Which shall we choose? An average of the three is .22 second. This is, perhaps, as near the truth as we can get. Curve I. shows that the two distributions stand about .20 second apart all the way through. I have, therefore, taken .20 second as a conservative measure of the difference. What is the reliability of this measure? The formula for the unreliability of a difference is as follows: "The unreliability of a difference between *A* and *B* equals the square root of the sum of the square of the unreliability of *A* and the square of the unreliability of *B*." By this formula the unreliability of this difference is .04. This figure means that there is a divergence of .04 second of this difference from the true difference.



Curve I.

A less abstract notion of the reliability of this difference is obtained from a study of Table XIII. where the difference of each

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[4] E. L. Thorndike, "Mental and Social Measurements," p. 193.

subject is given. Also in the curve I. where the total distributions are plotted the same constant difference is shown. It will be noted that this curve compares the two series neither by subjects nor by tasks but by the relative frequencies at the various points on the scale. Thus by all these methods we find a fairly well-defined and constant difference.

There are two possible interpretations to be placed on this difference. In the first place it may be interpreted as "set-time." Assuming that the subject does not fully get set in the .15 sec. fore-period allotted to him, he takes this difference off at the beginning of the main-period to complete his set, then deals with the stimulus word as previously when he got completely set in the main-period. If this is true then the process of experiment II. is just the same as in experiment I., the only difference being that here the fore-period process overlaps into the main-period and that part of the fore-period time or set-time is included in the main-period. If this be true then we cannot regard this experiment as fulfilling the conditions under which preparatory set is at a minimum.

A second interpretation of this difference is that it is association time. If we assume that in the .15 sec. fore-period the subject merely gets task-notion without task-set and sometimes the task-notion is inadequate, and if we assume that he gets no further set in the main-period, then we can conclude that he must deal with the stimulus word unprepared. If this interpretation be true, then we have conditions under which the preparatory set is at its minimum or at least reduced to a low degree. Evidence for the truth of this interpretation can be found by correlating the two sets of measures. The fore-period in experiment II. was of course constant throughout, and difference between main-periods of these two experiments is a variable. If this variable is "set-time," that is time taken in preparation, it ought to vary in the same general direction as the fore-period time of experiment I. That is to say, if in experiment I. a subject took a relatively long time to get set, one would expect to find the difference between the main-periods of experiment I. and experiment II. relatively long for that individual, —if the difference was taken up in getting set. Thus the correlation between this difference in the main-periods with the fore-period of experiment I. would be high. Similarly if it is "set-time," it ought to correlate as high with the main-period of experiment I. as does the fore-period of experiment I. Table XV tells its own story.

From this table we are justified in concluding that the factors that cause variation in the fore-period of experiment I. are not the same as those causing variation in the difference between

TABLE XV

Task	F.P. Exp. I with D	M.P. Exp. I. with D	M.P. and F.P. Exp. I
Opposite	.213	.522	.374
Whole-part	.097	.460	.304
Part-whole	.035	.218	.208
Subordinate	−.293	.706	.568
Verb-object	−.042	.691	.431
Averages	−.048	.519	.377

main-periods of the two experiments. On the other hand the difference correlates higher with the main-period of experiment I. than does the fore-period of experiment I. This seems to be strong evidence favoring the second interpretation of this difference, namely, that it is association time.

This conclusion is further verified by some introspective reports taken from time to time throughout the experiment. A sample introspection is as follows: "I just read the task words as they flash by and try to take a passive attitude toward them. At first I tried to maintain a tense attention but later found that the better way was to relax the attention and barely read the task words. When the stimulus appears I sometimes have to go back and think again what the task was, but very seldom. The method by which I get my response is by allowing the stimulus to suggest anything it will, they try out these various suggested responses until I get a correct one." I asked one subject to define as clearly as possible the difference between this process and that employed in experiment I. He replied that in the former case the reactions seemed for the most part "automatically passive" while here they seem "critically active." That is to say, in the first experiment when he had all the time necessary for preparation he felt sure that after the set had been accomplished it would do the work in the main-period without any more conscious effort; whereas, in this case one must be more on one's guard in the main-period and deal more critically with the suggested responses.

When some of the subjects were engaged in this experiment I noted that they moved their lips rapidly when the stimulus word appeared, as though they were repeating the task over again. At the end of the experiment I made inquiry regarding this and found that some subjects denied having moved their lips at all, and others confessed that they were repeating the stimulus words. This is another point of evidence favoring the supposition that the subjects were dealing with the stimulus words ill-prepared.

To test still further the conclusion that we have in this experiment the conditions for minimum preparation, I devised a third experiment which I have referred to as experiment III. It is just the same experiment II. except that the fore-period is lengthened to .35 sec. If the "difference-time" that we have just been considering is set time, this difference added to the .15 sec. fore-period of experiment II. should make a fore-period of sufficient length to yield a main-period as short as the main-period of experiment I. That is, a fore-period of .15 + .20 sec. should be just as effective as one .88 sec. long.

The following table gives a comparison by tasks of experiment I. with experiment III.

TABLE XVI

Comparison of the Main-periods of Exp. I. and Exp. III.

	Exp. I.		*Exp. III.*		
Tasks	M.P.	P.E.	M.P.	P.E.	D.
Opposite	.95	.09	1.10	.11	.16
Whole-part	1.15	.18	1.30	.17	.25
Part-whole	1.09	.14	1.24	.21	.15
Subordinate	1.35	.24	1.50	.35	.14
Verb-obj	1.05	.16	1.19	.14	.14
Averages	1.118	.16	1.28	.19	.17

The main-periods of experiments III. are in every case longer than in experiment I. and in every case except one shorter than experiment II. The median of the total distribution of experiment II is 1.22 sec. with a probable error of .21 sec. The fact therefore that the main-period of experiment III. is .17 sec. longer than the median main-period of experiment I. is evidence that a fore-period of .15 sec. + .20 sec. is not long enough to yield a main-period as short as the main-period of experiment I. The conclusion from this is that the .20 sec. difference between the main-periods of experiments I. and II. is not "set-time," for if it were, one ought to be able to get a fore-period long enough to yield a main-period as short as that of experiment I. by adding this difference to the fore-period of experiment II.

In the light of the foregoing considerations we seem justified in concluding that the experiment II. furnishes the conditions under which preparatory set is at its minimum and association time at its maximum.

III. The Ratio Between the Fore-period and the Main-period.

In order to determine the ratio between the fore-period and the main-period it is necessary to know two things. In the first place it is necessary to know the length of the main-period when the fore-period is zero; and in the second place we must know the minimum time required for the maximum set.

The first of these requisites was fulfilled by a special experiment (Exp. IV.) in which I eliminated the fore-period by presenting the stimulus simultaneously with the task. With ten of the original 15 subjects and with stimulus words of about equal difficulty to those used in experiments I. and II., I took about 600 reactions. I shall compare the results of this experiment with those of experiment I. since we have here what seems to be the maximum main-period, and in experiment I. the minimum main-period.

TABLE XVII

Comparison of Exp. I. with Exp. IV. by Subjects

	Experiment I.		*Experiment IV.*	
	Med. M.P.	P.E.	Med. M.P.	P.E.
(1)	.97	.10	1.37	.15
(3)	1.27	.15	1.91	.16
(4)	1.19	.11	1.80	.21
(5)	1.12	.12	1.38	.15
(6)	1.02	.05	1.37	.17
(8)	1.09	.15	1.63	.22
(9)	1.19	.11	1.88	.24
(10)	.90	.12	1.39	.14
(13)	.96	.12	1.42	.16
(15)	.97	.08	1.62	.15
Averages....	1.068	.11	1.577	.17

This table shows a difference of about half a second between the main-periods of the two experiments. By comparing the medians of the total distributions we get approximately the same difference. Here again is the problem of determining whether or not this difference is consumed in preparation or in dealing with the stimulus word. The introspections seem to indicate that in most cases it is "set-time." A sample introspection is as follows: "At first, I attempted to deal with the entire sentence stressing the stimulus word. I found that this was difficult and seemed slow. Later I adopted the method of stressing the task words first and ignoring the stimulus until I had the task well in mind. Then when I turned my attention to the stimulus the response came readily." Another subject testified that when both task and stimulus is given at once he got no set at all. He paid little attention to the task words as is evidenced by the fact that he read "opposite" as "object" twice. Another found that by reading the task twice before passing to the stimulus he could get a quicker response. These introspective reports show that at first most subjects attempted to deal with the stimulus word at once without regarding the task, but upon finding out the difficulties involved in doing this, they later adopted the method of giving a little time at the beginning to getting a set.

These introspections would seem to indicate that sometimes this difference of .50 between the main-periods of experiments I. and IV. (IV. being the experiment with a fore-period of zero) is partly "set-time" and partly association time. There is one other consideration, however, that would seem to indicate that it is "set-time." Applying the same reasoning to this case as we applied to the case above when we said that if the difference between the main-periods of experiments I. and II. is "set-time" then the difference added to the fore-period of experiment II. ought to make a fore-period long enough to yield a main-period as short as experiment I.—I say, applying this reasoning here, the .50 sec. difference between the main-periods of experiments I. and IV. ought to make a fore-period long enough to yield a main-period as short as the main-period of experiment I. Now, the fore-period of experiment IV. was zero, and adding to that the difference between main-period of IV. and the main-period of experiment I. which is .50 sec. gives a fore-period for an experiment which actually did yield a main-period as short as the main-period of experiment I.

The second desideratum for determining the ratio between the fore-period and main-period is that of finding the minimum time required for the maximum set. In experiment I. we concluded that we had the conditions under which one got the maximum set, but more time was taken, on the whole, than was necessary to get it. What is the minimum time to get it? This would best be determined experimentally by gradually increasing the fore-period until the main-period decreased to the same length as the main-period of experiment I. In order to save time I first calculated the length of this fore-period from the data at hand and later verified my results experimentally. I found the length of the fore-period which yields a main-period as short as that of experiment I., to be about .50 second. (See curve No. II.) Thus we may call .50 sec. the minimum time for adequate preparatory set.

To find the exact ratio between the fore-period and the main-period it would be necessary to begin with zero fore-period and increase it gradually, say by steps of .05 second up to .50 second, —taking a large number of reactions at each step in order to insure reliable measures of the corresponding main-periods. Since the time is not at our disposal to measure the actual lengths of the main-periods at each successive step on such a fore-period scale, the best we can do is to calculate the ratio from the data we have at hand.

The results of this entire investigation are summed up in Table XVIII. The table tells its own story and requires no further comment. For the purpose of determining the ratio between the fore-period and the main-period let us consider only the summary columns at the bottom of the page. Disregarding experiment I. in which the fore-period was unlimited we have four fore-period measures, 0, .15, .35 and .50. Their corresponding main-periods are the medians of the total number of reactions in that experiment. This number is given in the extreme right-hand column,—Curve III. shows the total distribution for each of these experiments except experiment V. the distribution of which is about the same as experiment I. See Curve II.

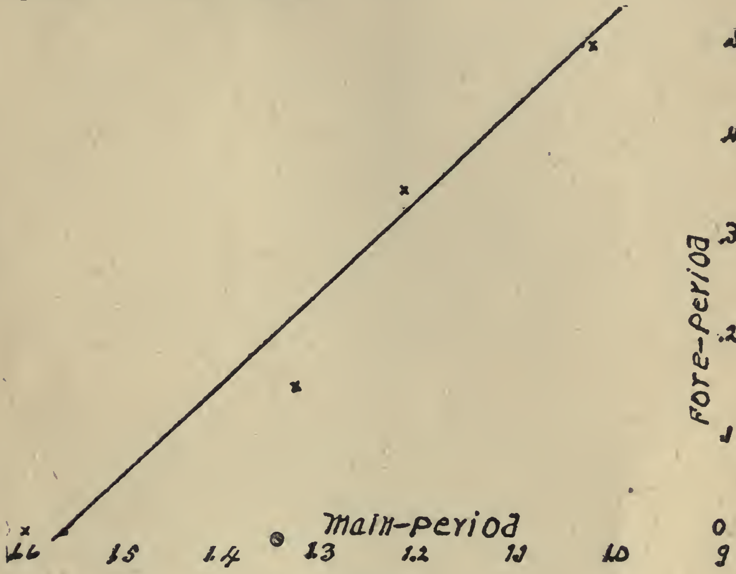

Chart I

It will be noted in the summary, Table XVIII., that as the fore-period increases from zero up to .50 second the main-period decreases. What is the ratio of the decrease in the one to the increase in the other? In chart I. the main-periods are plotted on the horizontal scale and the fore-period on the vertical scale, and the intersection of the fore-period and main-period of each experiment is indicated with a cross. Assuming that the relation here is rectilinear, a line drawn so that the sum of the squares of these crosses from it is the minimum will represent the desired relation. The equation of this line is $x = -1.05y$.[5] By substituting $(X - 1.30)$

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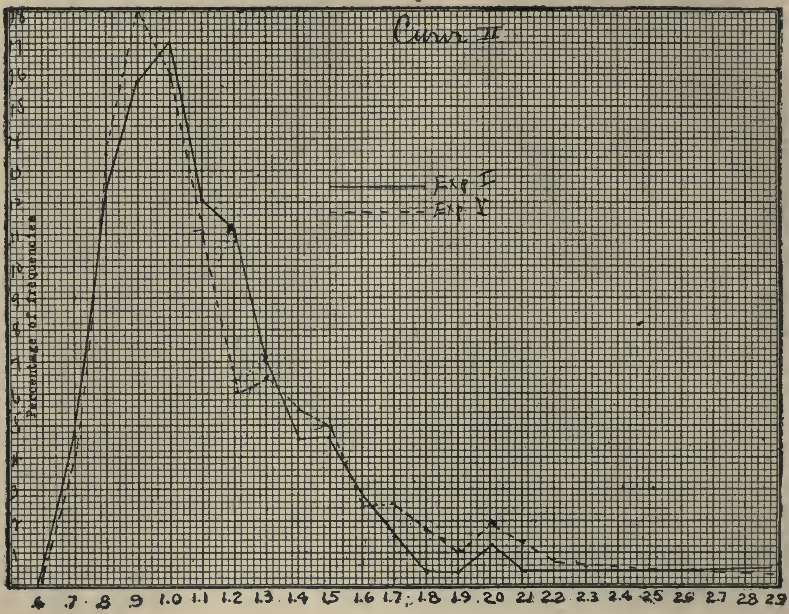
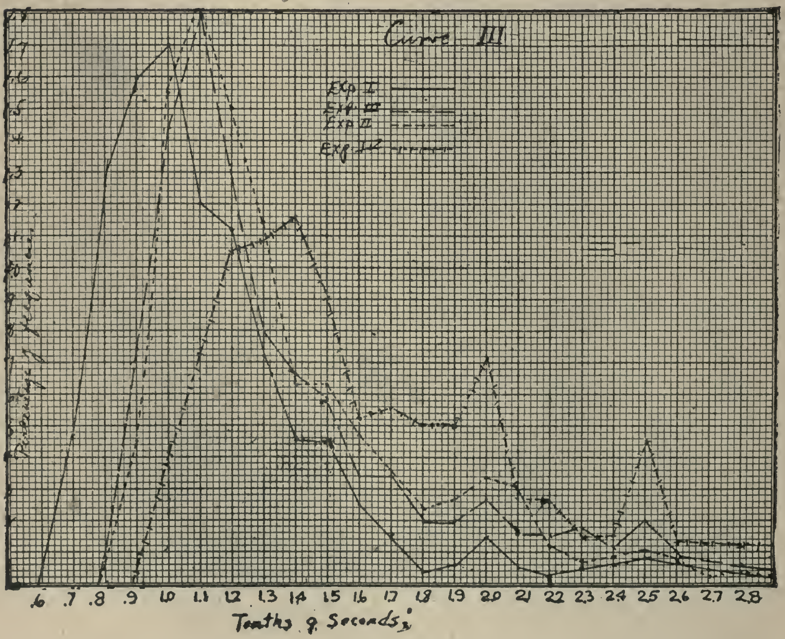
[5] This equation was derived from the formula for regressions which is

$$x = r \, . \, \frac{\sigma_x}{\sigma_y} \, . \, y$$

In this case $r + - .977$, $\sigma_x = .204$ and $\sigma_y = .190$. See Yule's "Theory of Statistics," p. 179.



CURVE II



CURVE III

TABLE XVIII

	Opposites				*Whole Parts*			
Exp.	F.P.	M.P.	P.E.	FP+MP	F.P.	M.P.	P.E.	FP+MP
(I.)	.88	.951	.09	1.831	.88	1.150	.18	2.130
(V.)	.50	.821	.08	1.321	.50	1.040	.05	1.540
(III.)	.35	1.110	.11	1.460	.35	1.301	.17	1.851
(II.)	.15	1.150	.11	1.300	.15	1.259	.20	1.409
(IV.)	.00	1.287	.13	1.287	00	1.625	.37	1.625
	Part-wholes				*Verb-objects*			
(I.)	.88	1.094	.14	1.974	.92	1.039	.16	1.959
(V.)	.50	1.010	.10	1.510	.50	.900	.15	1.400
(III.)	.35	1.244	.21	1.594	.35	1.185	.14	1.535
(II.)	.15	1.308	.25	1.458	.15	1.193	.16	1.243
(IV.)	00	1.500	.24	1.500	00	1.657	.31	1.657
	Subordinates				*Supra-ordinates*			
(I.)	.91	1.356	.24	2.266				
(V.)	.50	1.350	.20	1.850	.50	1.050	.18	1.550
(III.)	.35	1.500	.35	1.850	.35	1.425	.16	1.775
(II.)	.15	1.591	.26	1.741	.15	1.368	.20	1.518
(IV.)	00	1.935	.26	1.935	00	1.400	.36	1.400

SUMMARY

Medians of the Total Distributions.

Exp.	F.P.	M.P.	P.E.	MP+FP	No. of Measures
(I.)	.88	1.05	.18	1.93	750
(V.)	.50	1.03	.20	1.53	600
(III.)	.35	1.22	.21	1.57	600
(II.)	.15	1.33	.22	1.48	1125
(IV.)	00	1.60	.28	1.60	700

for x, and $(Y - .25)$[6] for y, we get $X = 1.56 - 1.05Y$ or M.P. = 1.56 − 1.05 F.P. Substitute various values of F.P. in this equation we get the following:

		P.E.
F.P. = 0	M.P. = 1.56	.04
F.P. = .05	M.P. = 1.50+	"
F.P. = .10	M.P. = 1.45	"
F.P. = .15	M.P. = 1.40	"
F.P. = .20	M.P. = 1.35	"
F.P. = .25	M.P. = 1.30	"
F.P. = .30	M.P. = 1.25	"
F.P. = .35	M.P. = 1.20	"
F.P. = .40	M.P. = 1.15	"
F.P. = .45	M.P. = 1.10	"
F.P. = .50	M.P. = 1.05	"

Let me repeat that this work is highly unreliable on account of insufficiency of data. To test the accuracy of this measure of relationship it would be necessary to perform a large number of experiments, beginning with a fore-period at zero and constantly increasing it by steps, say of .05 sec., up to .50 second. This would give a series of ten measures from which one could compute with a fair degree of accuracy just what the relationship is, and whether it is rectilinear or a curve. My conclusion is that *as far as my data go*, they show that the ratio between the fore-period and main-period is about 100 to 105.

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[6] .25 is the average of all fore-periods. 1.30 is the average of all main-periods.

CHAPTER VIII

CONCLUSIONS

THE principal results of this investigation can be summed up in the answers to the three following questions:

(1) What is the *nature* of preparatory set?

When stated in this form the question is difficult to answer. If we ask the dynamic question rather than the static one, it will read: What are the processes involved in getting set for an associative reaction? I have attempted to distinguish two general processes here, the first of which I have called "task-notion" and the second "task-set." Speaking generally task-notion is the process of understanding the meaning of the task words or apprehending the relation stated; task-set is the process of getting specifically ready to do a specific task, or in Ach's terms, the setting up of the determining tendencies. This might be regarded as a psychological analysis of the process of getting set.

On the physiological side I have ventured to propose the theory that the neural mechanism of task-notion is essentially a distributing mechanism; and that of task-set is a converging mechanism. The evidence for this theory is given in Chapter VI. The writer is frank to admit that the process of getting set for an associative reaction is so extremely complex that any attempt to spell it out in neural terms is almost absurd. The only value that can be claimed for any such a hypothesis as this is that it enables one to account in a general way for the facts revealed by this investigation, and is perhaps a starting point for the working out of an explanation of the processes involved in this highly important function.

(2) What kind of influence does preparatory set exert on associative reactions?

The answer that I have given to this question is that its influence is twofold: inhibitive and facilitating. At first it may seem that these two terms simply denote the positive and negative aspects of the same thing; that is, the presence of one implies the absence of the other. This may be true logically but not psychologically. I have cited cases in which the set seems to have inhibited all wrong responses and all right ones, save one, but did not operate to facilitate this right one; on the other hand, there are instances in which it facilitated the right one but did not inhibit wrong ones or many right ones from crowding in. There are thus at least four possible spheres of influence: (*a*) Both inhibition and facilitation, (*b*) inhibition without facilitation, (*c*) facilitation without inhibition, and (*d*) neither facilitation nor inhibition. These are given here in the order of their frequencies in the investigation.

On page 49 I pointed out that the predominance of task-notion in the fore-period tends to favor facilitation in the main-period; and that task-set in the fore-period tends to favor inhibition in the main-period. This is merely a striking observation the validity of which I have by no means established. Thinking of it in neural terms, we might say that in the fore-period, if the subject only gets a task-notion and attempts to deal with the stimulus word without the task-set, the task-words, by hypothesis, excite the distributing centers which in turn sub-excite the pathways leading out from them, making ready a number of responses; if the stimulus word appears at this instant, other things being equal, a number of responses will tend to come to the threshold of consciousness and the subject will be faced with the difficulty of choosing one from among them. This sort of thing actually happened in a great many instances throughout the investigation. If, on the other hand, the subject gets the task-set in the fore-period as well as the task-notion, impulses coming from other areas of the brain and from certain parts of the body will, by hypothesis, be focused or converged on one of the sub-excited pathways, or perhaps on distributing mechanism, and will put in a nascent state of excitement one path which, according to a well-known law of nerve action, will make it the favored one, and will inhibit all others. Here again I must say that this is almost a fanciful theory and is devised solely for a better understanding of the facts of this investigation.

(3) How much influence does preparatory set exert on an associative reaction?

This question can never be answered absolutely, since by hypothesis no reaction is possible without some sort of preparation for it. But it can best be answered by subtracting the main-period time of the experiment in which the preparatory set is supposed to be at its maximum from that in which it is at its minimum. The results show that complete preparatory set shortens the association time from about 10 to 25 per cent.

Another interesting conclusion to be drawn from the investigation is that the total time of the entire performance is shortest when the preparatory set is at its minimum. That is, Table XVIII. shows that the total time is shortest in experiment II., that is when the fore-period is limited to .15 second. The practical conclusion is that the total time taken in the solution of a problem can be shortened by taking a certain part of it for the complete understanding of the problem before attempting a solution.

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